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PRODUCT ENGINEERING

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MECHANICAL
DESIGN

PRODUCT
DEVELOPMENT

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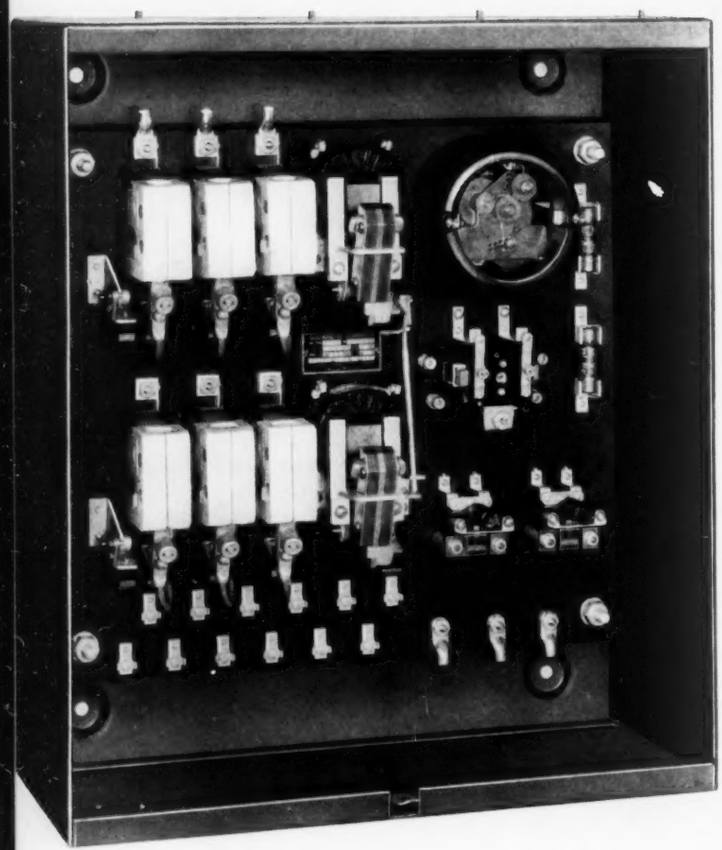

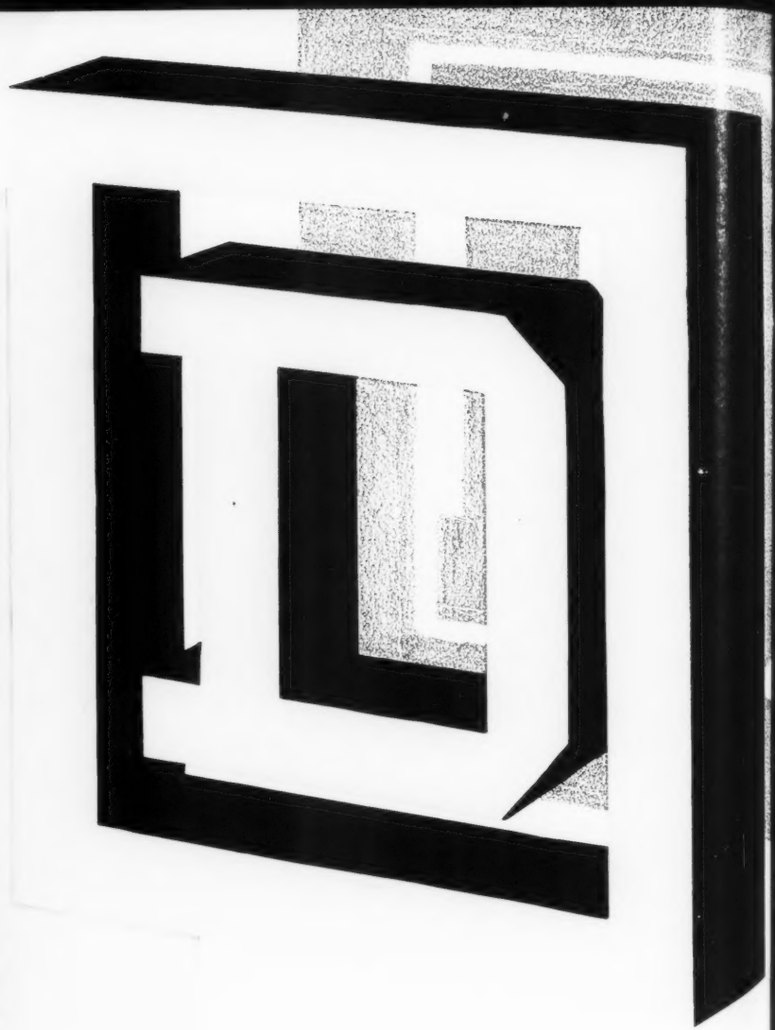

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PRODUCT ENGINEERING

VOLUME 5 NUMBER 12

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Coming Issues

Built-in lighting equipment must be designed with adequate knowledge of how much illumination is required and how to obtain it. This information will be given a prominent place in the January number.

Other articles will include an inquiry form listing all the information needed for specifying sleeve bearings, the second installment of the series on stampings, and articles on screws and locking devices, and stresses in cams.

Trends in automobile design will be featured in the February number showing the results of a survey now being made covering recent applications of improved materials, parts, finishes and types of construction used in the 1935 models.

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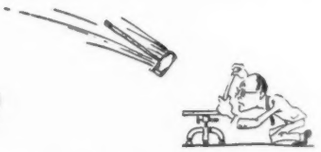
Intimate Correspondence



An Apology

Spoiling what was otherwise an excellent record for production efficiency on the November number of *Product Engineering,* on the part of all concerned, inside and outside our organization, an error in our mailing department mixed up the sending out of the personal copies that had been promised to the many engineers who contributed information. As a result we do not know surely which ones received these copies and which ones did not. If a copy was promised you and none has arrived we shall be much indebted to you if you will let us know. We take this means to make our apology and try to make up for the error because we have no other way of reaching the individuals who have been unintentionally slighted.

Superlatives

PRODUCT ENGINEERING
NEW YORK

Regarding your November issue, it deserves a lot of superlatives. It's quite breath-taking in its extent and I have not yet digested it. It must have been the result of an endless amount of work and certainly your graphic presentation of facts concerning the new products and processes should inspire and encourage designers to the improvement of all manufactured products.

I read with a good deal of interest an article on a similar subject in your October number by Robert Wosak, giving specific figures of the saving in a diesel engine by the use of the improved materials. There are many facts therein that I have to take the writer's word for, which I am content to do, even though the results are astoundingly in favor of the new products. We hope the good work will go on and that designers will go to these two issues for their inspiration.

CARL P. NACHOD
Louisville

WE join Mr. Nachod in the pious hope that designers generally will go to the October and November issues of *Product Engineering* for inspiration. And we hope also that they will continue to read *Product Engineering* for this reason, and to get practical design facts and methods as well.

Good Designers

PRODUCT ENGINEERING
NEW YORK

At this point I want to say something about your article about "Learning Rule and Rote Does Not Make a Designer." I heartily agree with you on the shortcoming of engineering education in this respect. To my own sorrow I have learned that it is very hard to find men who will make good designers—designers that have the ability to analyze a problem, a practical view, a good foundation of physics, vision, the ability to stray off the beaten path when hunting for a solution, and artistic sense. There are dozens of other things a good designer should know, but where does he have a chance to study the fundamentals?

It would be a grand idea if the engineering colleges would start a course teaching the fundamentals of design.

I once heard a harassed chief engineer say, "We can always hire an engineer, but where can we get a good designer?"

I have read your magazine for years and appreciate your articles dealing with successful products and progressive ways of doing things. I must confess that reading them started me often on a new line of thought that eventually led to the solution of some problem. More power and success to your publication.

ROBERT WOSAK
Philadelphia

ALL that Mr. Wosak says is true. But it is a question how far an engineering school can go in developing initiative and vision. Some people believe that those qualities are more likely to be inborn than to be acquired. At the same time we may as well recognize the fact that present conditions call for an ample supply of them, and that the more we think about ways of developing them the more likely we are to find a successful way.

Costly Metals

PRODUCT ENGINEERING
NEW YORK

Referring to an article in your October issue entitled "Saving Money by Using Costly Metals," I can only compliment you on its publication. Though this article refers specifically to diesel engines, there are many other fields in the industry where this thought applies.

In recalling the readers' attention to this article, I endeavor to impress the importance of this trend of development towards a better and more efficient product by employing costlier materials and saving money through proper application of the advanced knowledge in design and product engineering.

OTTO HOFFMANN
Buffalo

THIS letter requires little by way of comment. We appreciate Mr. Hoffmann's indorsement of the article in question, and judge from other letters that have come in that he is not alone in his opinion.

Necessary Evil

PRODUCT ENGINEERING
NEW YORK

Yes, I do read the advertisements and get a lot of real value from them when it comes to trying to have the most of modern equipment. However, may I suggest that perhaps the engineers are endeavoring to keep ahead of the times more than their employers are. A large number of steel plant executives seem to consider the engineer as 'A necessary evil,' and a lot of times allow others in their plants to do as much if not more engineering work than the engineer who has spent a life time at his profession. In other words, they fail to get the full value from his services, they spend a lot of money to get us to read their advertisements, but will not give any of their time toward trying to understand why we are in a position to give them service that only engineers can.

C. ARTHUR FULLMAN
Huntington Park, Calif.

WE believe that Mr. Fullman is a bit too pessimistic in his belief that employers generally, and steel plant executives in particular, look on engineers as a "necessary evil." Yet there is just enough of this attitude extant to warrant engineers in taking steps to overcome it. That was one of the primary reasons for starting *Product Engineering.*

WR^2

PRODUCT ENGINEERING
NEW YORK

As this late date I want to compliment you on the presentation of the article on WR^2, which appeared in the October issue.

This article certainly goes a long way towards accomplishing what I had in mind and, while it may prove helpful for other fields as well, want to express my particular appreciation form the standpoint of motor design.

F. E. HARRELL
Cleveland

PRODUCT ENGINEERING
NEW YORK

The writer has read the article "The Significance of WR^2 and How to Calculate It," by John W. Harper, which appeared in the October issue of *Product Engineering.*

We would like very much to have a copy of this article for our Research Department records. It gives a very satsfactory and understandable description of calculating WR^2. We feel that it will be helpful in our work.

Elwood City, Pa.
J. R. PARKHILL

THESE are only two of many similar letters complimenting the WR^2 article that have reached us. It took months of effort to get that article in its final form, and it is therefore gratifying to learn that it "clicked."

PRODUCT ENGINEERING

KENNETH H. CONDIT, *Editor*

MCGRAW-HILL PUBLISHING CO., INC. DECEMBER 1934 VOLUME FIVE, NUMBER TWELVE

Will Your Products Sell?

AS ANOTHER difficult year draws to its close we come to the time for analyzing past performances and planning for the new year about to open. It is open season for the engineering and development department as new products or redesigned ones are studied by the various departments concerned with their manufacture and sale. And it is the time when accurate estimates of the course of future business are essential if the top management is to plot a safe course, and if the engineers are to design products that meet the needs of the buyer.

Indications of business improvement are becoming more numerous, although it is true that the business curve is not a smooth sine wave. The Pennsylvania Railroad's recently announced order for fifty-seven new electric passenger locomotives is an encouraging indication; so is the fact that automobile production in 1934 will be far ahead of the 1933 figure, and that plans of several of the big producers call for an increased output in 1935; also that retail sales are up thirteen per cent. These are but a few.

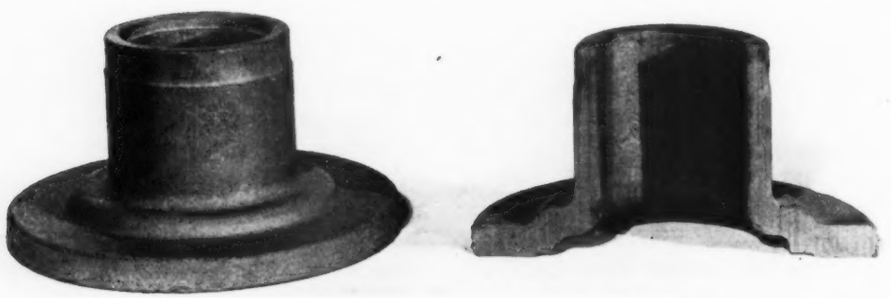
Let us admit that specific instances of business improvement are not necessarily typical. But the real picture is to be formed if we dig deeper into what has been going on in the engineering departments and research laboratories of companies making machinery and metal products either for the consuming public or for the industrial plants. New standards of accuracy and performance have been set up, and new products that obsolete the old ones have been developed.

Today, machine tools five years old are more out-of-date than corresponding tools built in 1910 were in 1925. Modern locomotives are so much more efficient than old ones that they are paying for themselves in less than five years; diesel-electric streamlined units when applied to some kinds of service operate at costs that turn losing divisions into profitable ones. The automobile of today is not only better built and better looking than those of only two or three years ago, but handles so much more easily that it is a revelation to those of us who are still condemned to drive the old family chariots.

DURING the last four years the proportional amount spent on research and development by progressive companies has risen considerably. Despite curtailed production and negative balances these companies have pursued a policy that has been both consistent and persistent. They are in a position to profit as the business tide rises. While there are companies that have found it expedient or unavoidable to follow a policy of watchful waiting rather than one of aggressive action, the average of product development activity for all companies is ahead of the figure of 1933, as indicated by the product development survey published in November *Product Engineering*. Belated returns of our questionnaires show that the number of engineers on development work this year is greater by sixteen per cent than the corresponding figure of a year ago. This comparison is a tribute to the courage of the industry and portends better business to come.

Stampings-I
Parts Produced by Swaging

J. K. OLSEN
Formerly Chief Draftsman, Stewart Warner Company



Courtesy Parish Pressed Steel Company

Fig. 1—Hub flange for automobile rear axle housing with flange ½ in. thick, neck 3⅛ O.D. and 2⅝ I.D.

IN ADDITION to the conventional bending and shearing of sheet stock, the cross section can be swaged within limitations during stamping operations. Sections can be enlarged, upset or "cold forged" to a moderate extent with steel, and to a greater degree with aluminum and brass using conventional, inexpensive punch press dies and equipment. And, as shown by the following examples, swaging can be used to add many desirable features in stamped parts.

In providing a counterbore, swaging can often be used to advantage. After punching a hole smaller than the diameter of the counterbore and slightly larger than the desired hole, an additional operation displaces the metal back to the desired size of hole, as shown in Fig. 2. The wall of metal included between the diameters *A* and *D* for a depth *C* is swaged into the portion of *E* to form the finished hole diameter. The volume of displaced metal in the counterbore equals the volume of metal required to reduce the diameter of the hole to the finished size. This operation has limitations but it is applicable to most common proportions and eliminates a separate machining operation.

Chamfers, shown in Fig. 3, require similar swaging operations, single or double chamfers being incorporated directly in the stamping dies. The single chamfer usually is used where a part is to be pressed into the hole, the chamfer acting as a guide. When a hole is to be chamfered by swaging, a small allowance in the size of hole as punched is provided if the chamfer is to be large. But often the actual operation is one of compressing the material rather than swaging it. In such cases the diameter of the punched hole will not be affected appreciably by the swaging operation.

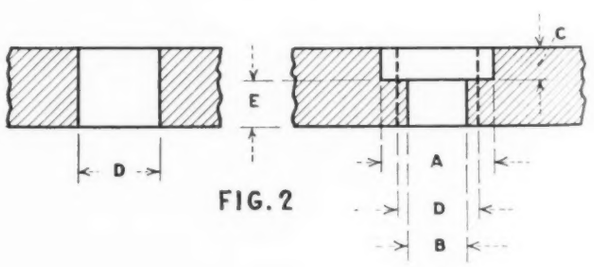


FIG. 2

Quite similar to swaged chamfers, and also in common use, are swaged holes for flat or oval head machine screws and wood screws. Three typical designs are shown in Fig. 4. In the first design, the chamfer is shaped for stock thicker than the height of the screw

head. In the second, the diameter at the surface is depressed so that after assembly the top of the screw head will be below the surface of the sheet.

Chamfers for flat head screws in thin metal are swaged as shown in the third design in Fig. 4; when the sheet is the same thickness as the height of the flat head screw this design is used. When the thickness of stock is less than the height of the flat head screw, the same design is used but the diameter of the clearance hole for the screw is made larger than the diameter of the shank of the screw to provide a flat cylindrical edge in the hole instead of a sharp edge or fin. When thin stock is used the allowance for the flat edge is generally 1/10 of the thickness of stock.

Also readily obtained by swaging is the ordinary setback, in which metal is upset and replaced for dowels, hubs and swelled ends. An article on this subject appeared in *Product Engineering,* August and October, 1932. In Fig. 5 are shown three typical designs.

Another simple swaging operation is used to place small depressions such as spots or notches in the surface of the stock. In Fig. 6 are shown two examples of this type of swaging in which the spots or notches are used for projection welding or for locating other parts.

In the first design in Fig. 6 a series of depressed notches provide a snap effect required for snap switches, or the notches can be used to locate a pointer. In this design the depression is forced directly into the surface of the metal. The second design shows swaged spots used for projection spot welding.

When a rough surface is needed around holes a series of radial serrations can be swaged, as shown in Fig. 7. These serrations will have a tendency to keep a part from turning when tightened up against them, especially if the attached part is a soft material such as fiber. Serrations can be put on one or on both sides of the stampings.

Some forming operations distort the metal to such an extent that the operation partakes more of the nature of swaging, as in the part shown in Fig. 8. Also, when stock is too heavy for forming to the desired shape, swaging can be used to advantage. The shaping of a pointer, as shown in Fig. 9, is a typical example. There is also an opportunity to use swaging for ornamental purposes as shown in Fig. 10, in which the ornamental design around a screw head adds to the appearance. Other ornamental designs can be obtained in this manner when the metal has a chance to flow into the desired shape.

Swaging also is employed when a draw is required to stretch the material. Fig. 11 is an example of a stamped part in which a good swaging operation is required to obtain the angular lug design shown.

Closely associated with the swaging of stamped parts is the swaging of round parts, extensively used for flattening of the end of rods, as shown in Fig. 12. The first design is a plain swaging of the end of a rod, but this flattening operation can also be made on a threaded rod with the lug offset and bent as shown in the second example.

It is common practice to swage drive keys to make them an integral part of the round rods. The size of the key is limited by the maximum allowable proportion of size.

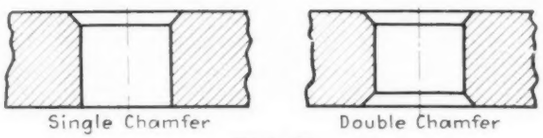


FIG. 3

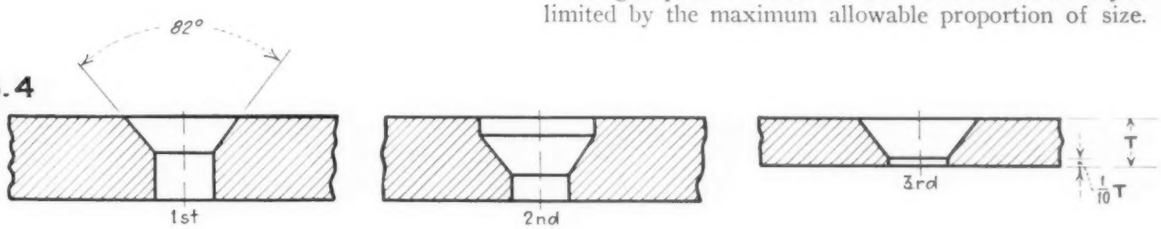


FIG. 4

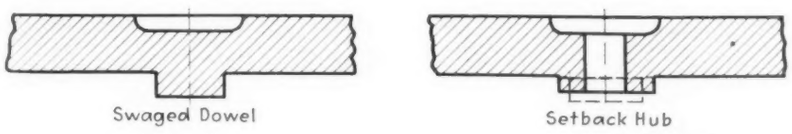
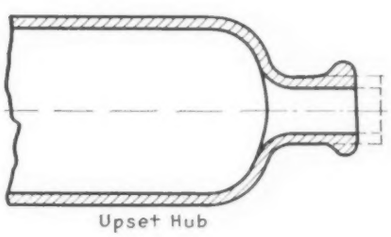


FIG. 5



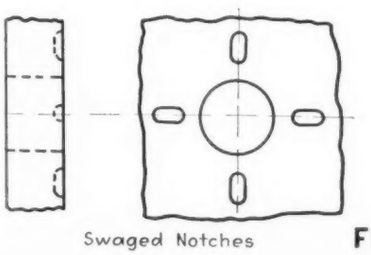
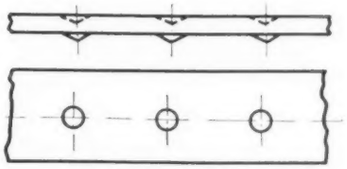


FIG. 6



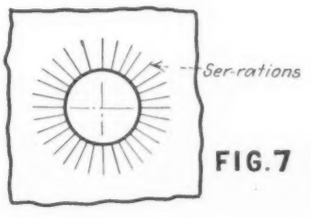


FIG. 7

of rod to the size of key. For a single key the key body cannot have a volume of material more than approximately one-half of the volume in an equal length of rod. The projection *A* in Fig. 13 is obtained from the replaced material from spaces *B*. The thickness of the lug *C* should never be extremely small as the metal will have a tendency to crack if forced too much. Although proportions given are approximate, it is always advisable to avoid extreme designs. In Fig. 14 are two actual examples of parts with swaged keys.

A double key or lug design as shown in Fig. 15 is another example of a swaged key.

One of the most common swaging operations is forming a square on a round rod, as shown in Fig. 16. Although this is sometimes done directly on a round rod, in most designs a turned-down portion is swaged so that the corners of the square will not extend beyond the diameter of the shaft.

Two examples of swaged square parts are illustrated in Fig. 17. A square drive shaft as shown could be used with a stamped part with a square punched hole of a size suitable for one of the above square portions to enter. The proportions for the square hole, as given in Fig. 18, should provide a close fit for the square swaged shafts shown in Fig. 17. Other shapes such as triangular, hexagonal and combinations can be used also.

When a square swaged shaft fits into a hollow shaft that has a square swaged hole, the proportion of the diameter of the round hole in relation to the size of the inside square hole must be made so that the circumference of the hole equals the perimeter of the square.

It is sometimes necessary to decrease the diameter of the section that is to be swaged less than the outside diameter of the shaft, as shown in Fig. 19. But when it is necessary to maintain the outside diameter of the shaft, the swelled-out corners can be removed after swaging.

Corners on swaged square shafts or square swaged holes should not be made sharp. In common practice the hole is made slightly smaller than the distance across the corners of the square swaging.

In Fig. 20 are two typical parts having a square driving portion incorporated in a

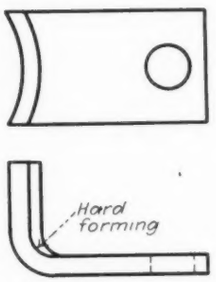


FIG. 8

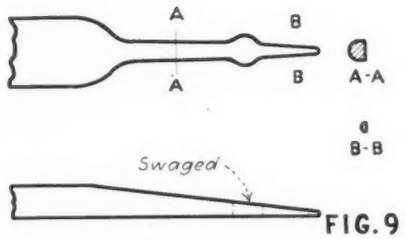


FIG. 9

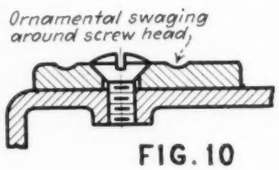


FIG. 10

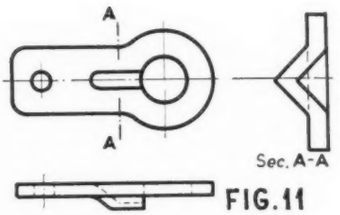


FIG. 11

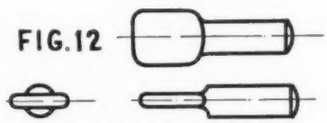
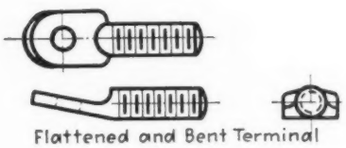
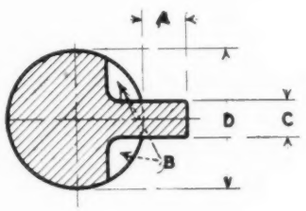


FIG. 12





A = Max. $\frac{1}{3}$ D C = Min. $\frac{1}{4}$ D

FIG. 13

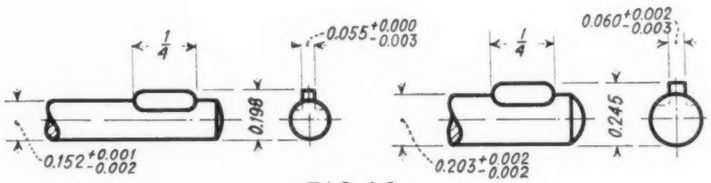


FIG. 14

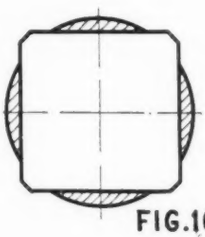


FIG. 16

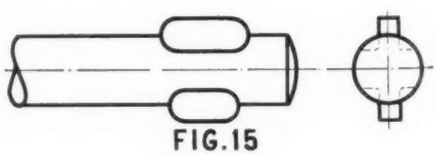


FIG. 15

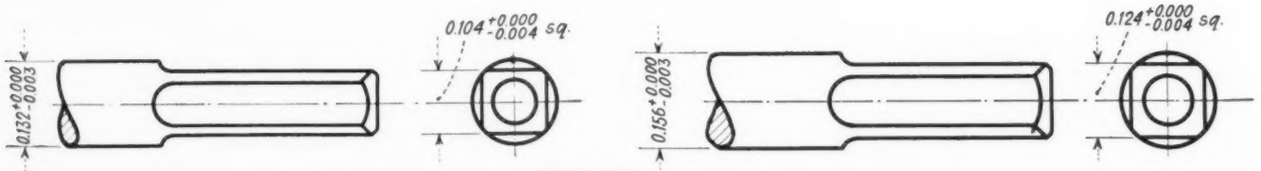


FIG. 17

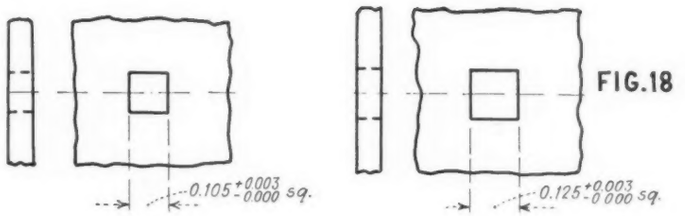


FIG. 18

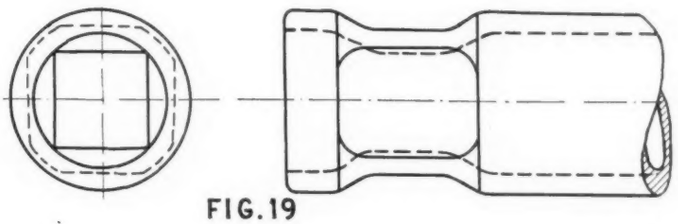


FIG. 19

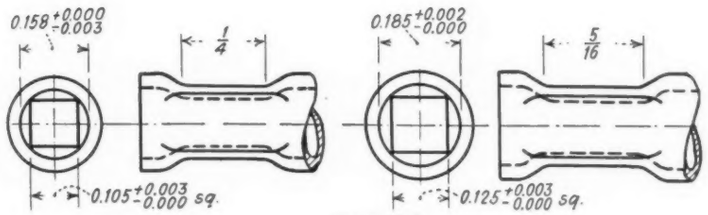


FIG. 20

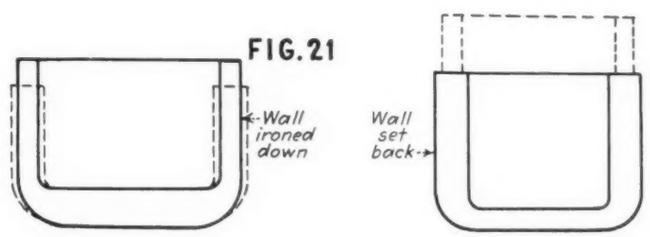


FIG. 21

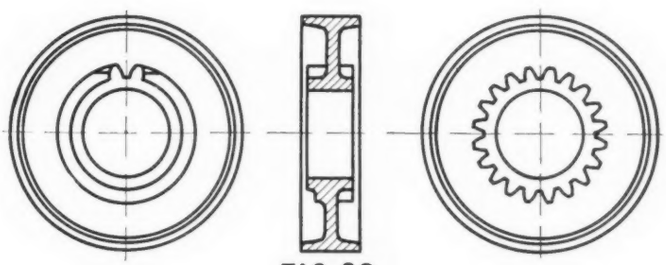


FIG. 22

round hole, and for purposes of comparison the same relations are used as for the swaged square drive shafts shown in Fig. 17. If the shafts are to be hardened, an allowance of approximately 0.002 in. should be made for shrinkage in the square portion.

Even in the drawing of shells, there are examples where swaging is used, as in a drawn part where the bottom and sides are not of the same thickness. In the first example shown in Fig. 21 the difference in the thickness is obtained by ironing or stretching the drawn shell. In the second example, the difference in thickness between the bottom and the sides is obtained by a setback or by upsetting the wall of the drawn shell.

Another example of completely swaged parts are the two aluminum pieces shown in Fig. 23. As can be seen, these parts can be designed with many features unobtainable in ordinary stampings.

Complete parts swaged from aluminum, brass or steel is a recent development. No general rules can be applied to the design of such parts as each design has its own peculiarities. One example of this process of swaging complete parts, shown in Fig. 22, incorporates both gears and segments directly with the dials in the registering units in an odometer. Swaged parts of this kind are generally made from round disk blanks with both thickness and diameter held to close tolerances. The blanks are stamped out of strips in the same manner as other round blanks with the ordinary allowance for scrap between blanks and between blanks and edge.

In calculating the size of blank needed, the blank diameter d is,

$$d = \sqrt{\frac{1.273 \times \textit{volume of the part}}{\textit{thickness of blank}}}$$

Volume calculations usually can be simplified by breaking the part into regular figures such as cylinders or prisms. Volumes of revolution can be calculated by multiplying the area of the rotated plane figure by the circumference swept through by the center of gravity of the plane figure. For complicated parts it may be best to make a model and measure or weigh the volume of liquid it displaces when submerged in water.

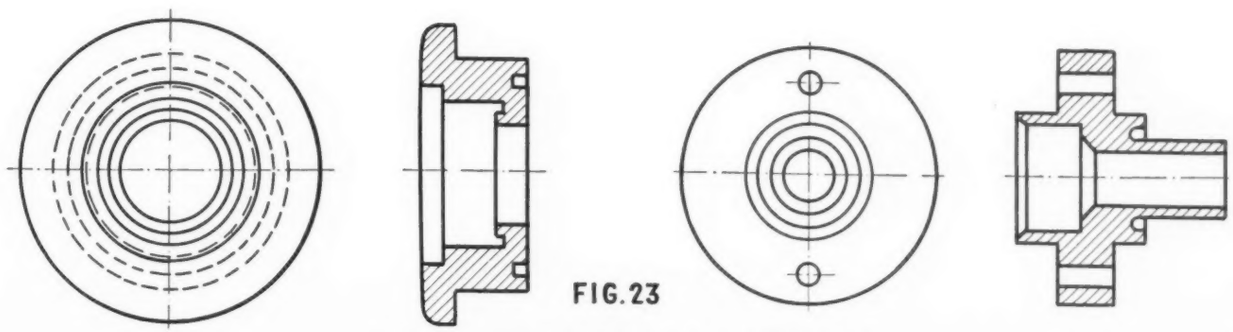
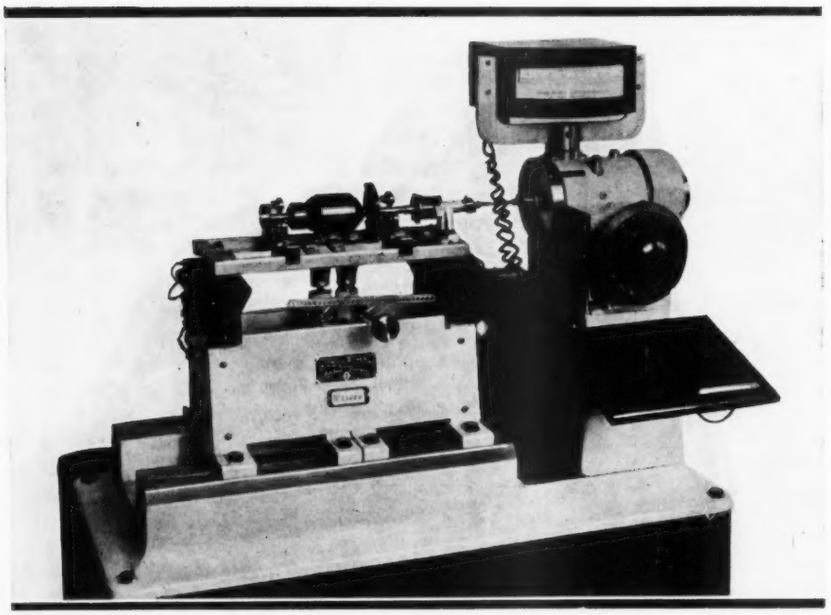


FIG. 23

PRODUCT DEVELOPMENTS



Electrical means of obtaining the amount of unbalance and its position eliminates all mechanical contact with the bearings supporting the armatures tested in the Tinius Olsen balancing machine

Dynamic Unbalance Registered Electrically

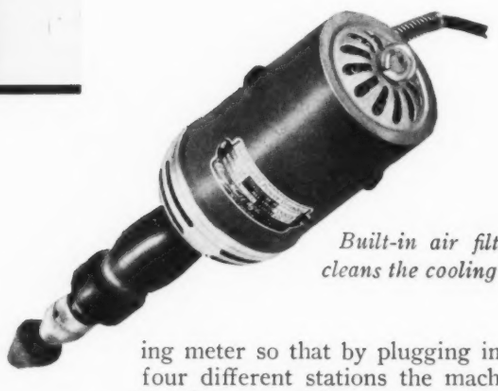
In static or dynamic balancing of small motor armatures, unbalanced forces are so small that mechanical means for indicating unbalance lack the required sensitivity. In the balancing machine shown here, built by the Tinius Olsen Testing Machine Company, the armature to be balanced is mounted in a cradle on two roller bearings held in place by spring-mounted retaining rollers. The retaining rollers are so designed that the armature revolves about its true center of gravity. If the armature is not in rotating balance, the bearing support vibrates a small steel plate in the field of a stationary electromagnet. Thus, an alternating current is generated, the voltage being proportioned to the displacement, and the phase depending on the position of the unbalance. A commutator on the drive shaft rectifies this current which is read on a direct current indicating instrument.

Angle of unbalance is obtained by rotation of dual brushes on the drive shaft commutator. Graduations on the dial attached to the driving head indicate the position of the unbalance, while the degree of unbalance is measured by the pointer deflection of the instrument mounted over the head.

Since all mechanical connections are eliminated between the rotating armature and the indicating system, the forces required to register the measurements will not affect the unbalance of even the smallest armatures. And with electrical indicating means, sensitivity can be increased as desired. Angle of unbalance is said to be indicated to the nearest deg., while an unbalance of only 5/10,000 in.-oz. can be found.

To obtain the maximum accuracy and sensitivity, together with the high production, the rotors are balanced at a comparatively high speed, using a speed higher than the critical speed of the balancing machine. Only under these speed conditions can such high accuracy and reliability be obtained.

The machine is provided with resistance in series with the indicating meter so that by plugging in at four different stations the machine has four capacities as to maximum amount of unbalance that can be indicated. The position of the unbalance on the armature is found by rotating the graduated disk on the drive shaft until a fixed pointer indicates the angle shown by the dial reading. Separate indications are given for each end.



Built-in air filter cleans the cooling air

• *Filtered Air for Grinder Motors*

To protect the high-speed motor in the portable grinder made by the Chicago Wheel & Manufacturing Company, ventilating air is drawn into the motor through a viscous-type filter, shown at the top of the tool in the above illustration. Dust and abrasive matter removed from the air collects in the filter which

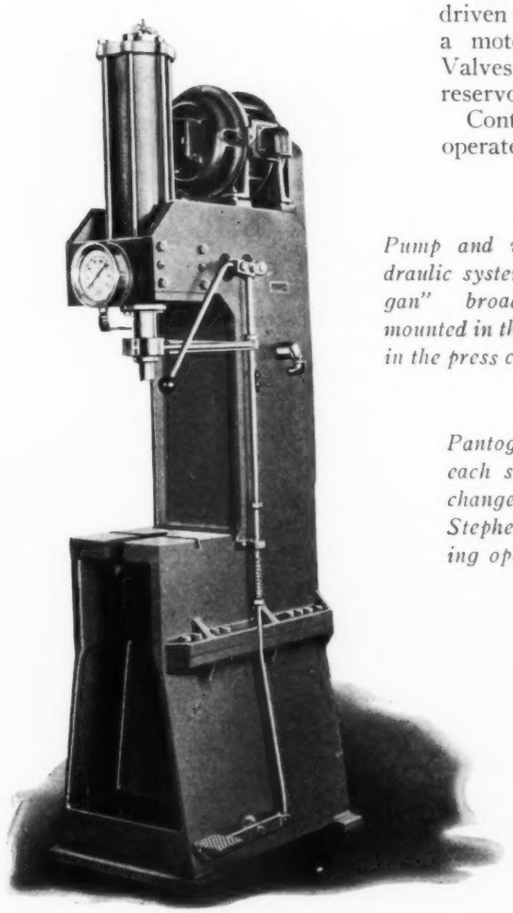
can be easily removed for cleaning and re-oiling. Even when the filter is loaded with dirt, ventilation is said to be adequate.

With a cast aluminum housing the tool weighs but 4 pounds. The motor operates at 17,000 r.p.m. and has sufficient power to operate a grinding wheel 2 in. in diameter.

• *Hydraulic Broaching Machine*

Welded construction is used throughout in the design of the new hydraulic forcing and broaching press developed by the Logansport Machine Company, shown in the illustration. Oil for the hydraulic circuit is contained in a reservoir in the press column, and the oil pump, mounted inside the reservoir, is driven through a chain drive from a motor on top of the column. Valves also are mounted within the reservoir.

Control valves are foot or hand operated, downward movement of the control lowering the ram. Automatic or manual reverse is effective at any point of the down stroke. At the top position of the ram oil bypasses the pump, so that with the ram in this position the pump does not work against pressure. Length of travel is adjustable by means of a stop rod with adjustable stops.

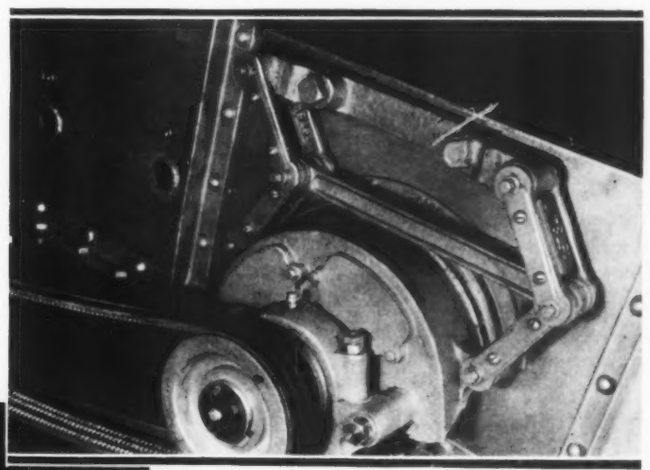


Pump and valves for the hydraulic system used on the "Logan" broaching press are mounted in the oil reservoir within the press column

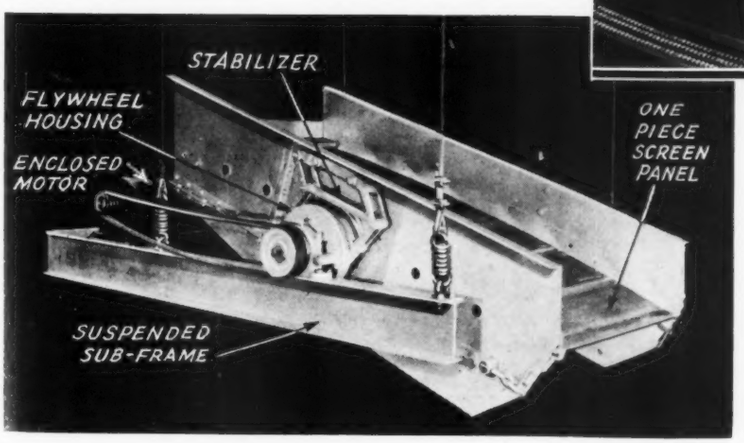
• *New Separator for Storage Battery Plates*

A new form of vulcanized sheet rubber is now being used by the Electric Storage Battery Company, for separators between the plates of their batteries. These sheets of rubber are permeated with countless microscopic passages that permit the free diffusion of the electrolyte. So small are these passages that the most minute solid particles of active material are prevented from passing through.

These separators are not affected by the electrolyte solution in the battery and are said to be immune to the heat that might be developed in the battery.



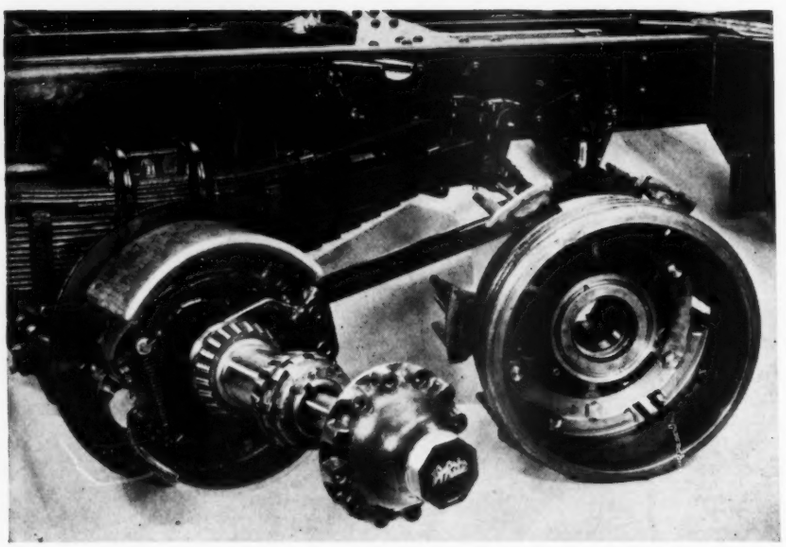
Pantograph suspensions used at each side of the screen prevent changes in the screen angle of Stephens-Adamson screens during operation



• *Pantograph Suspension for Vibrating Screens*

In vibrating screens, the screen body should move freely without altering the screening angle. The pantograph suspension used on the Stephens-Adamson screen not only maintains the screening angle throughout the stroke, but also re-

Low-cost alloy steels used in the body of the Baltimore & Ohio hopper car give four to six times the corrosion resistance of carbon steel



Brake drums on White trucks are heat-treated to produce different properties as required throughout the part

Battery-less flashlight has a dynamo running in bearings molded in the case

stricts the vibration of the screen to one plane.

As shown in the accompanying photographs, at each of the two sides parallel arms are fastened, one end of the arms being fastened to the main bearing, and the other end to the screen body.

• *Low-Alloy Steels for Corrosion Resistance*

Railroad rolling stock provides a logical application for the new low-cost corrosion-resisting steels such as recently announced by the Carnegie Steel Company. As used on the Baltimore & Ohio car shown above, increased resistance to the effect of outdoor exposure makes possible a smaller allowance for corrosion, while the increased strength imparted by the alloy additions allows the use of higher working stresses with further weight reductions.

Since only moderate alloy additions are used, these steels are not corrosion proof, but they do have much greater resistance to oxidation than ordinary steel. The addition of 0.5 to 1.5 per cent chromium, 0.5 to 1.0 per cent silicon, and 0.3 to 0.5 per cent copper increases resistance to atmospheric corrosion by 4 to 6 times.

Other alloys having two to three times the resistance of ordinary steel use a manganese content of about 1.5 per cent with 0.2 per cent copper or 0.3 to 0.7 per cent chromium.

• *Heat-Treated Brake Drums*

Through "differential hardening," a closely controlled heat-treating process, brake drums used on White trucks, as shown above, now give five to six times longer life. Accurately controlled temperatures in combination with a carefully developed heat-treating cycle are said to be responsible for greater improvement than would be obtained through the use of possibly an entirely different material. The "dif-

ferential hardening" produces structures and physical properties that are varied throughout the brake drum to provide the qualities desired at various sections of the part. It is claimed that the life of the brake drum is increased 500 to 600 per cent.

• *Motorized Billet Chipper*

Each function of the Bonnot "Billeteer," illustrated below, is performed by a motor designed to perform that operation. The carriage is driven by a two-speed low-inertia reversing motor designed for quick and frequent starting and stopping. The low speed is used in the cutting direction and the high speed reverse for the return stroke.

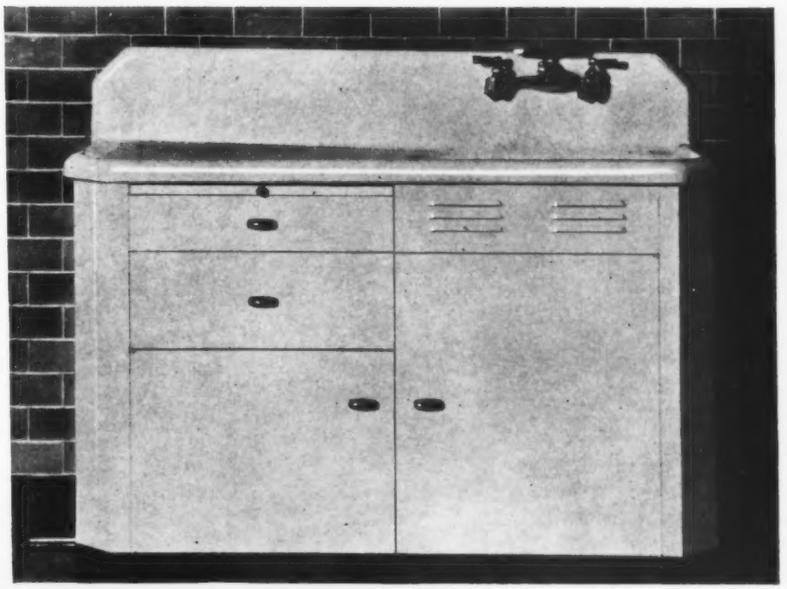
A vertical gear motor drive, built into the top of the carriage raises and lowers the tool head. This is a torque motor and turns but a few revolutions at each operation, which may be as frequent as 25 times per min.

The only standard motor on the machine drives the tool head, which runs continuously while the machine is in operation. Since the load is actually a series of peaks as the cutter teeth enter the metal, high maximum torque is required from the motor. High torque is required also from the manipulator motor mounted in a vertical position on the front of the carriage.

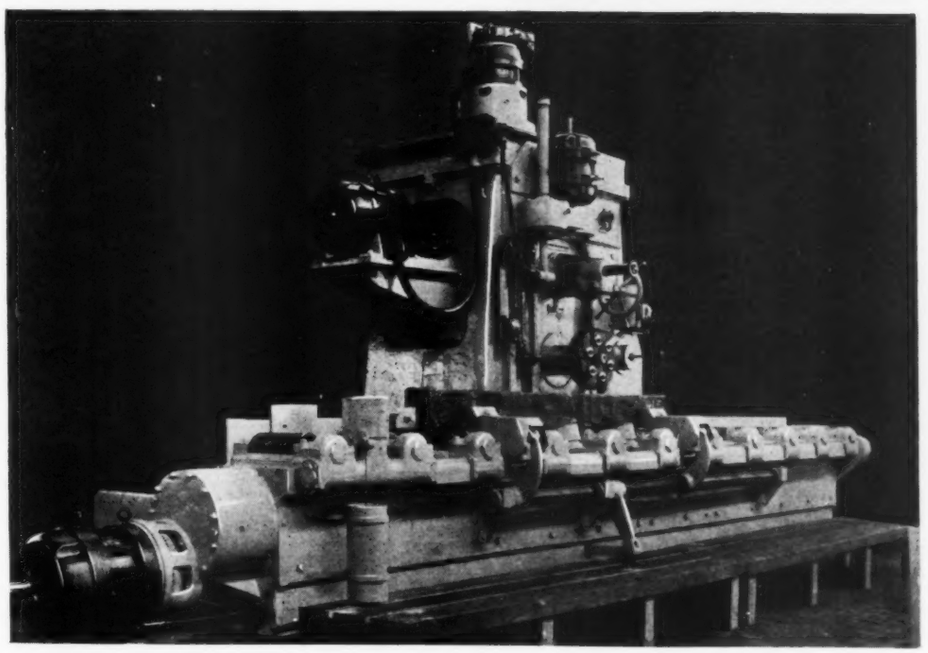
Two torque characteristics are required in the chucking motor, as greater torque is needed for releasing than for closing. The motor drives through an irreversible worm with primary resistance inserted in the motor circuit to reduce the torque during the closing stroke. The motor circuit is opened by a relay one sec. after the motor stalls when the chuck is closed.

Special intermittent-duty high torque characteristics are incorporated in the table drive motor, built on to the end of the machine.

Instantaneous control of all motors is provided by a compact control convenient to the operator. Raising the control knob raises the tool head; lowering the knob lowers the head. Moving the handle to right or left moves the carriage in the corresponding direction. When the knob is out full length, the cutter revolves. Pressing the control handle clear into the plate instantly stops every motor. Since every operation is centralized in the one control, the performance of the machine is greatly increased.



Reduced installation expense and greater use of available space are features of a new cabinet sink developed by the Youngstown Pressed Steel Company. The cabine is finished in porcelain enamel



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Each of the six Reliance motor drives on the Billeteer is designed to meet the particular load conditions for each drive. All controls are centralized in one convenient panel

How to Lay Out Optical Systems

For a given magnification, projection distance, image size and type of lamp, the accompanying chart gives the optical efficiency, the diameter of lens or reflector and its focal length

R. C. HITCHCOCK
Westinghouse Electric & Mfg. Company

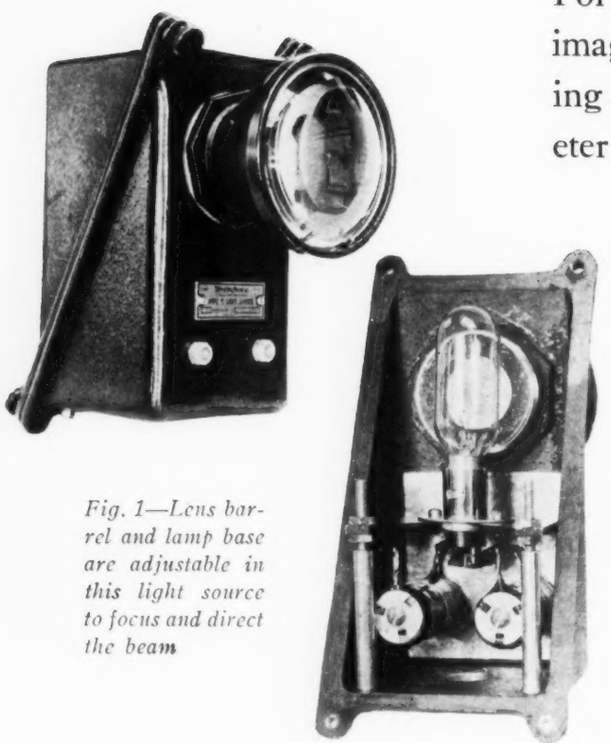


Fig. 1—Lens barrel and lamp base are adjustable in this light source to focus and direct the beam

OPTICAL systems are required to use effectively the radiation from a lamp source for inspecting small intricate parts, optical projection, spot lighting, and the operation of photoelectric cells and relays. The selection of the type of optical system and the position and size of lenses or reflectors depend on the nature and the size of the light source, the length of the beam with its accompanying magnification, the area to be covered, the precision of focus required, and the intensity of illumination desired. In general, photoelectric relays require a sharply focused, narrow beam, while other applications may need a more diffused spread of light.

The unit of light power is the lumen, a unit of light flux per second—analogous to a horsepower or a watt. Since light flux diverges from a source in straight lines unless focused or reflected, it is usually necessary to know how the flux is spread over a surface. To measure illumination the terms lumens per square foot (light power per square foot) or foot candles are used. But light intensity or illumination indicates neither the area covered nor the lumens (quantity) of light since illumination is the ratio of light power to unit area.

Just as a watt per square inch does not tell how many watts are being radiated, a foot candle does not tell how many lumens of power are available. The missing factor is area, and when the square feet over which the foot candles are spread is known, the power in lumens is obtained directly by multiplying. Thus quantity of light in lumens is equal to the intensity in foot candles multiplied by the area in square feet.

In designing a projection optical system such as shown in Fig. 1, six independent and four related factors must be considered: the size of the source, the central distance from the source to the lens, the lens diameter or aperture, the distance between lens or reflector and image, the size of the image, and the receiving aperture. And after laying out the optical design, the projector system usually requires adjustments for focus and direction of the light beam. Also, the lamp must be accessible for replacement, and provisions made for adjustment of the filament position. In the projector shown in Fig. 1, micrometer adjustment of the lamp socket is possible in the vertical direction, and the lens barrel can be screwed in or out to focus the image.

Most illumination problems require a given area to be illuminated with a specified quantity of light. The proper light source, magnification, and lenses giving the highest light efficiency can be obtained from the alignment

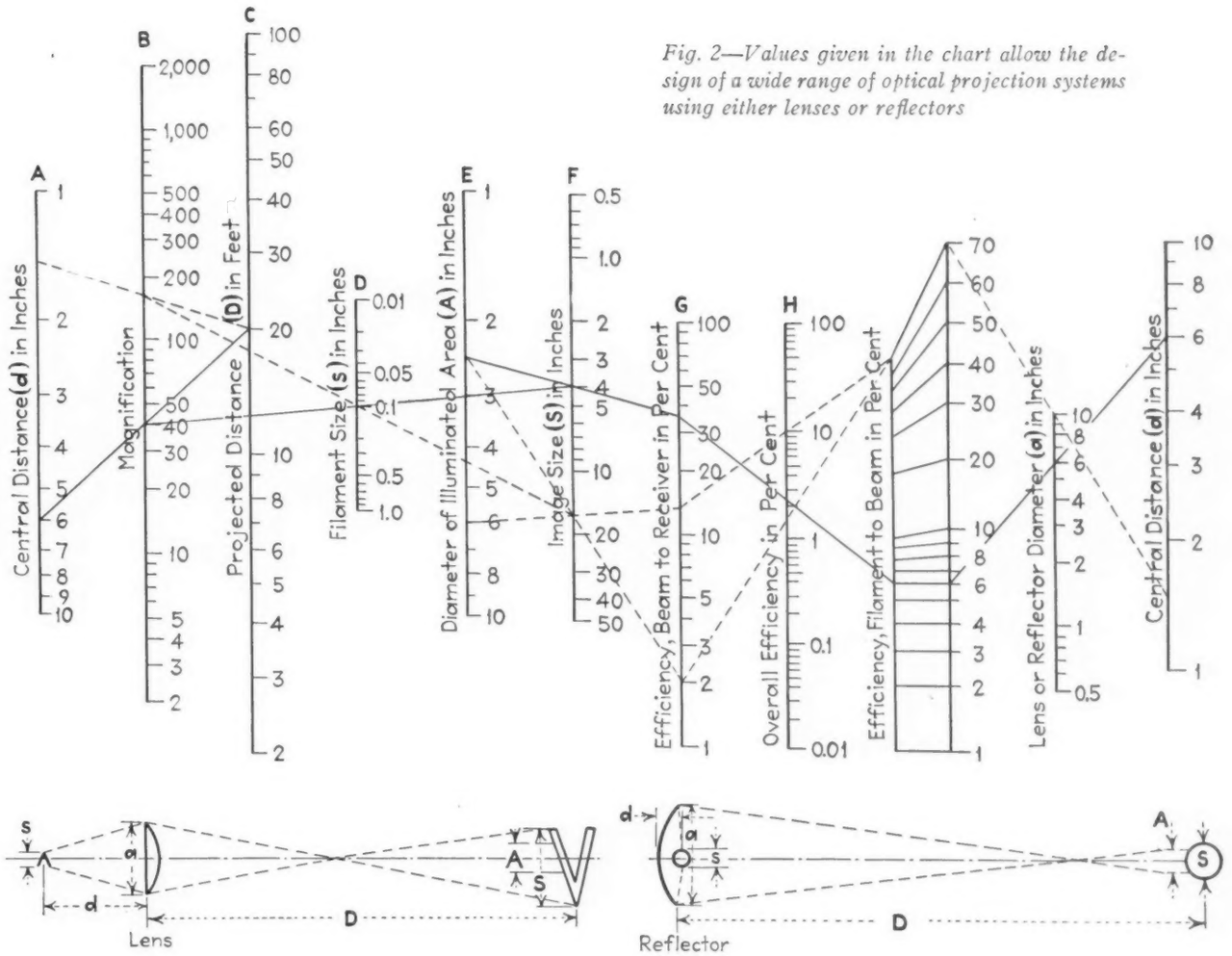


Fig. 2—Values given in the chart allow the design of a wide range of optical projection systems using either lenses or reflectors

chart shown in Fig. 2. For example, suppose that an area 2.5 in. in diameter must have 0.1 lumen of light supplied by a source 20 ft. distant. Since it is usually desirable to select an image or projected spot of light somewhat larger than the illuminated area in order to allow for misalignment, a 4-in. image is desirable to cover a spot 2.5 in. in diameter. Referring to the chart, aligning the 2.5-in. illuminated area, scale *E*, with a 4-in image size, scale *F*, the light efficiency from the light beam to the receiver, scale *G*, is 35 per cent. If the lamp used has a filament 0.1 in. high, scale *D*, the total magnification is found by aligning this point with the 4-in. image on scale *F*, and projecting to scale *B*, indicating a magnification of 40. With the image projected 20 ft., this distance on scale *C* aligned with the magnification of 40 shows that the lens required must have a 6 in. focus.

Efficiency of the System

Up to this point only the image size has been considered, but the efficiency depends upon the amount of the radiation from the source that can be concentrated in the beam. The bigger the lens for a given focal distance, the greater the amount of the radiation from the source, that will be directed into the beam. But the lens diameter or the diameter of the transmitting aperture usually cannot be greater than the focal distance. Using a lens diameter of 6 in. and a focus of 6 in. the three scales at the right of the chart show that the lens collects 6 per cent of the radiation from the filament.

The product of the efficiency of source-to-beam and the efficiency of beam-to-receiver gives an overall efficiency of 2 per cent for this optical system. This factor can be applied directly to the radiation of a source, after taking into consideration the absorption of light in the glass lenses and allowing for dirt on parts of the system. To take care of losses a multiplier of 10 is usually ample. If 0.1 lumen of light power is required in the illuminated area 1 lumen must be supplied to the optical system. With the overall light efficiency of 2 per cent the lamp source must send out 1/0.02 or 50 lumens. Since a mazda lamp emits 12.6 lumens per candle power, at rated voltage, 50 lumens will require 50/12.6 or 4 candle power.

The final solution of the problem then is a 4 candle power lamp, filament size 0.1 in., the light being collected by a lens 6 in. in diameter, having a focus of 6 in., delivering 0.1 lumen of light power at a distance of 20 ft. over the required 2.5 in. aperture. The light is radiated from 0.1 in. of filament. A larger lamp such as one of 50 candle power will produce a much larger image, but if the illuminated area is fixed in size, the larger lamp

will not deliver any greater quantity of light over the illuminated spot. However, the larger image will make the system less subject to trouble arising from possible misalignment.

Filament dimensions and candle power ratings are given in Fig. 4, for several standard lamps. For long life, incandescent lamps are frequently run at voltages lower than the rated values. A decrease of 10 per cent in the applied voltage decreases the light output by about 40 per cent.

Reflector Systems

Lenses provide well-defined images, and so do reflectors if a point source of light is available. But for a reflector a point source is not practical and consequently a reflector with a short focal length and large diameter produces a distorted image. When the light source is of appreciable size, as it is in practice, various points of the source cause multiple crossing of the images ahead of the focus so that the best obtainable spot of light from a reflector is not a clearly defined image.

Although a sharp image is not obtained, a reflector system can be designed from Fig. 2, using the chart in the same manner as explained for the lens. If a reflector with focus of $1\frac{1}{2}$ in. is used to project the same 20 ft., the first three columns show the magnification to be 170. With a filament size of 0.1 in., the image is 17 in., and if the same area is to be illuminated, the efficiency of beam to receiver is but 2 per cent. Using a reflector 10 in. in diameter with a focal length $1\frac{1}{2}$ in., the charts on the right show that 70 per cent of the light is directed. When multiplied by the efficiency of beam-to-receiver, the overall efficiency is 1.4 per cent, somewhat less than the efficiency of 2 per cent found for the lens system.

One peculiarity of a reflector system is that the image is much larger than obtained with lenses. This is an advantage when the illuminated area is a receiving lens for another optical system, because a larger receiving lens can be used without causing difficulty in alignment. Thus, if a lens 6 in. in diameter is used instead of the 2.5-in. lens, the efficiency of beam to receiver is increased to 14 per cent, and the overall efficiency of the system is 10 per cent.

For either lens or reflector systems the projection light source must be designed so that the light can be focused and directed. Locking means also must be provided to hold the desired adjustment under vibration and changes in temperature caused by heat from the operation of the lamp.

Reflectivity Factors

Mirrors placed in the optical system do not affect the system except for the light absorbed at the reflecting surfaces. As shown in Fig. 3, each reflecting material has a characteristic spectral reflectivity which varies with the color or wavelength of the light. Silver has the highest reflectivity, and is ordinarily used for mirrors in which the silver can be protected from oxidation. Although chromium has a low reflectivity in the visible region, this metal resists tarnish, and for practical purposes has much to recommend it. The same factor of safety of 10 used with lenses will ordinarily allow for the absorption of light at reflecting surfaces.

The final choice of either the lens or projector system thus depends on the requirements of the design. With greater magnifications and larger images reflector systems are usually more efficient and less expensive than equivalent lens systems. But where small, sharp images are desired lenses are preferable. For either lenses or projectors the alignment chart can be used to select the most efficient design.

Fig. 3—Metals for reflectors and mirrors vary widely in reflectivity at various wavelengths

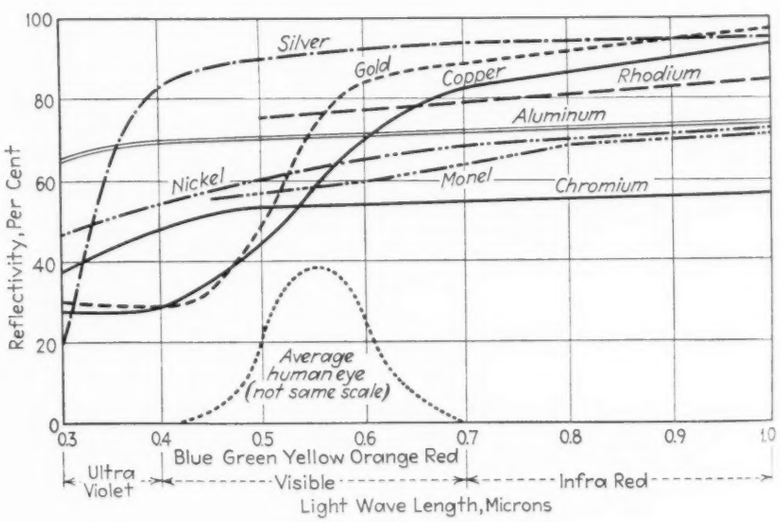
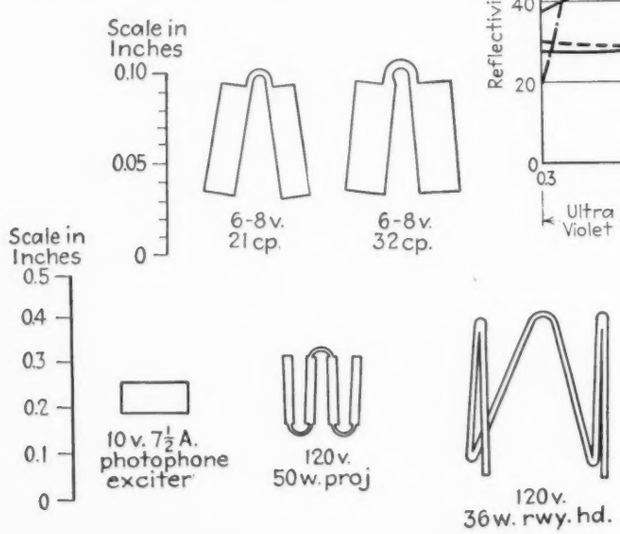


Fig. 4—Filament size, light output, and power requirements for several incandescent lamps



WHY the Elastic Modulus of Iron Is Not a Constant

Cast iron is a reliable engineering material, but only when the designer has available dependable data for the physical constants of the material that can be interpreted correctly, as explained by the author

J. M. LESSELLS
Consulting Engineer

ALTHOUGH for the past two centuries cast iron has had an important place in the industrial activities of all nations, it was not until the beginning of the present century that it can be said its production and application has been aided by metallurgical science. Today cast iron is receiving much attention and although the intensive development is welded structures may have displaced the use of cast iron from many special applications, there is no doubt that cast iron is a reliable engineering material with still greater possibilities in the future. The writer is only concerned here in making certain observations on some recently published material on this subject and in commenting on how such may influence design in general.

Reliable Data Required

After all is said and done the chief thing a designer is concerned about in his choice of working stresses is a proper understanding of test values. Working stresses are influenced considerably by material characteristics, and it is important that those data which are made available by the test engineer should be as reliable as possible. In no case is this as important as it is in the application of cast iron. If doubt as to the reliability of cast iron has been shown in the past, this may have been partly caused by the fact that the "constants" of this material have been shown to be erratic. This situation is rapidly changing, however, and the impractical data previously available on cast iron are giving place to data of a more basic character, such as the comprehensive data contained in the "Symposium on Cast Iron" published in the *Proceedings of the A.S.T.M.* 1933, page 15.

Nevertheless, in the compilation of material test values the metallurgical engineers probably have kept more in mind those tests which can be classified as control tests for the foundry, rather than tests for uncovering design information. This has been true in the past and it is true today. We recognize the metallurgists' point of view and probably cannot blame them for their attitude. Their chief function is to produce cheap and satisfactory materials, and suitable control tests represent their means of achieving this objective. It is within the domain of the engineer to criticize these tests so that design principles may become better established.

For the designing engineer, the test values in themselves are in many cases insufficient. It is also necessary to know the extent to which the stress and deformation to which the material was subjected in the test is analogous to that to which it will be subjected in service.

In designing parts to be made of cast iron, it is often of great importance to know the value of the modulus of elasticity of the material. The question of deflection is frequently the determining factor, rather than maximum stress. The problem is then to select the elastic modulus of the material from available test data. Here the designer will be confronted with a confusing array of figures.

To illustrate what we have said, let us consider the tests which are employed to determine E, the modulus of elasticity. This, of course, is one of the more im-

portant material constants. If steel is being used, a value of 30 × 10^6 lb. per sq.in. is a fairly representative value. For cast iron, however, values varying from 6 × 10^6 to 10 × 10^6 lb. per sq.in. are usually quoted. This divergence is too wide and more exact figures must be obtained. In all tests on cast iron, because of difficulties in obtaining basic data from a tension test, the modulus of elasticity values are calculated from tests in bending and are therefore only relative in character. A test bar supported at two points and with a concentrated load applied midway between the supports provides data from which the value of the modulus E can be deduced from the usual relation:

$$E = \frac{WL^3}{48\,I\delta}$$

W = Load in lb.
L = Span in inches
I = Moment of inertia
δ = Deflection at load in inches

The value of E obtained in this manner is only a relative modulus and is not as exact as can be obtained. In a recent contribution "The Elasticity, Deflection and Resilience of Cast Iron" by J. A. Pearce, published in the *Journal of Iron & Steel Institute,* 1934, it is suggested that the value of E be calculated on the elastic deflection at fracture of a standard bar. In other words, the point of fracture of cast iron might be regarded in the same way as the limit of proportionality in steels. This, of course, may be a metallurgist's way of regarding the matter but it cannot be the designer's. The hazards involved are entirely different because if in the loaded structure in service the modulus determined by the first method is exceeded, nothing but deformation occurs, while if the modulus determined by the latter method is exceeded, dire results may arise

Fig. 1—In releasing the load, material followed the abc *curves, and on reloading, the* cda *curves, the slope of the* ca *lines being the elastic modulus for the given load. Fig. 2—Modulus values as a function of stress obtained from the* ca *lines in Fig. 1. This partly explains the wide divergence in the value of the elastic modulus as reported by different investigators*

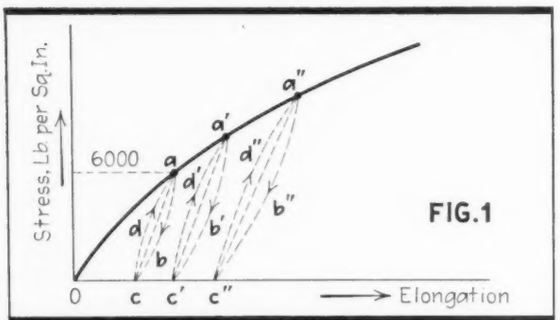


FIG.1

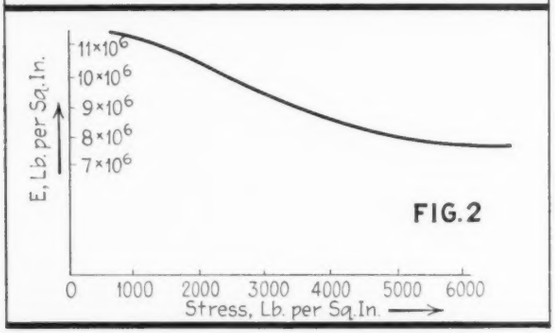


FIG.2

Variation of Modulus With Load

The question raised here is: Why is the determination of the value of E made so complicated? In the report previously referred to, a table of values is given which shows that E varies from 11.6 × 10^6 lb. per sq.in. for iron with a tensile strength of 15,000 lb. per sq.in. to a value of 20 × 10^6 lb. per sq.in. for iron with a tensile strength of 55,000 lb. per sq.in. Using sensitive extensometers it can be shown that ordinary cast iron is elastic up to stresses of the order of 1,000 lb. per sq.in. Knowing that the load-extension curve of cast iron is not a straight line for stresses in excess of 1,000 lb. per sq.in. for ordinary irons, why not obtain modulus values corresponding to given stresses? This would be the manner in which a designer would view the question.

Tests for obtaining modulus values for different stresses were supervised by the writer several years ago. Cast iron specimens were loaded in tension and by release of load at frequent intervals a relation as shown in Fig. 1 was obtained. After loading to 6,000 lb. per sq.in. and releasing the load, the material followed the line *abc* and on reloading, it followed the line *cda*. The line *cda* therefore represents the new stress-strain relation for a stress of 6,000 lb. per sq.in. and the modulus is represented by the line *ca*. By repeating this test for different stress values a relation such as shown in Fig. 2 was obtained, which gives modulus values as a function of stress. Such are more important to the designer since they tell him at once how this modulus value varies as load is applied.

To meet the needs of the operator of the machine, be it shop or office equipment, proper provisions for lighting should be provided as a part of the machine. In January Product Engineering will be told how much illumination is needed and how to provide it

Safe Loads for Journal Bearings

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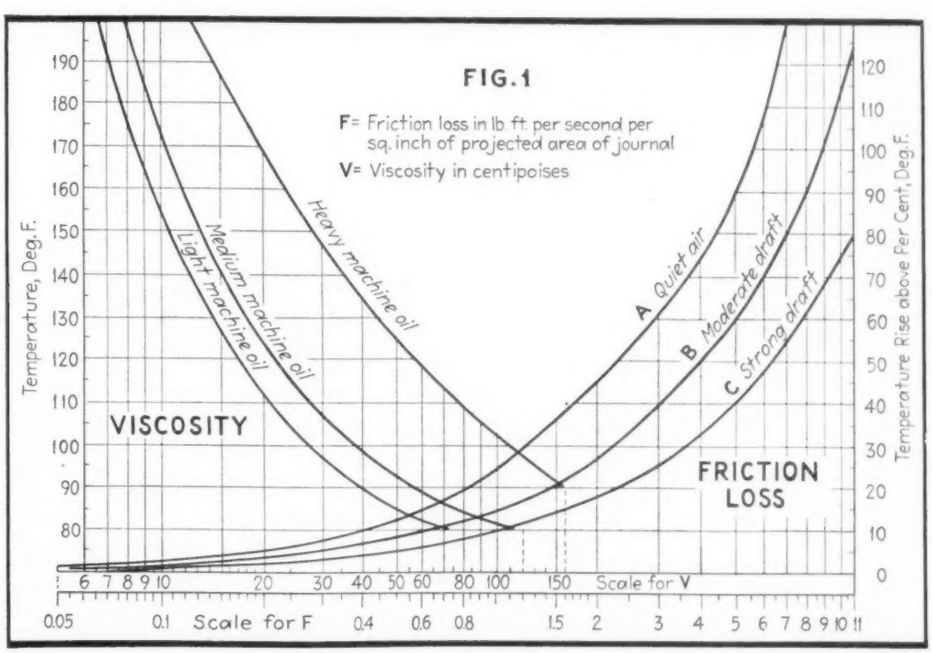
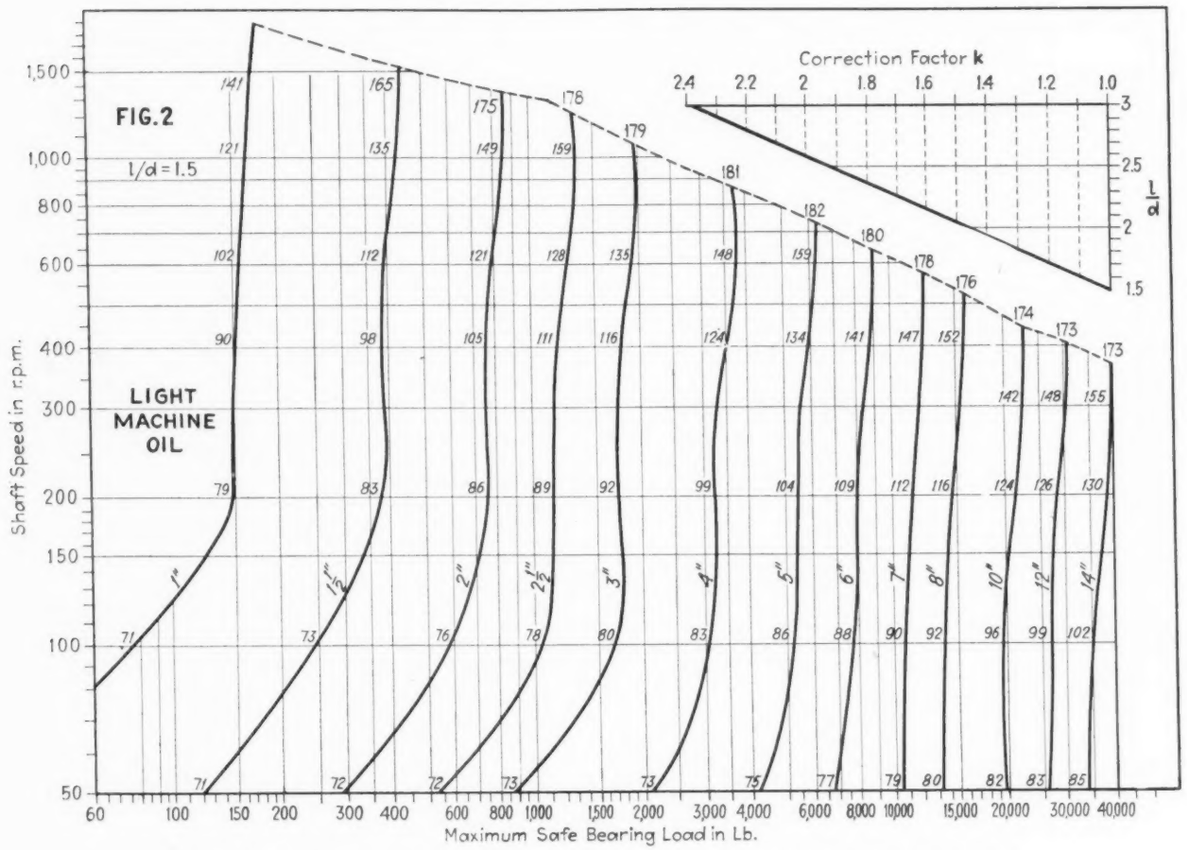
Charts included in the article give relations between journal dimensions, oil viscosity and temperature, shaft speed and maximum bearing loads for a wide range of designs

IN APPLYING the hydrodynamic theory of oil film lubrication to the design of journal bearings, the use of theoretical equations requires many time-consuming computations involving friction loss, journal loads, rotational speed, viscosity of the lubricant, temperature of the oil film and bearing clearance. The quantity of oil supplied to a bearing is also subject to a number of variables, and the actual bearing clearance has a large effect on the journal length and load capacity. By certain assumptions, these equations can be simplified to a set of curves for typical bearings under conditions that are frequently met. For conditions which do not fit the assumptions, these curves can be corrected as shown in the examples to follow.

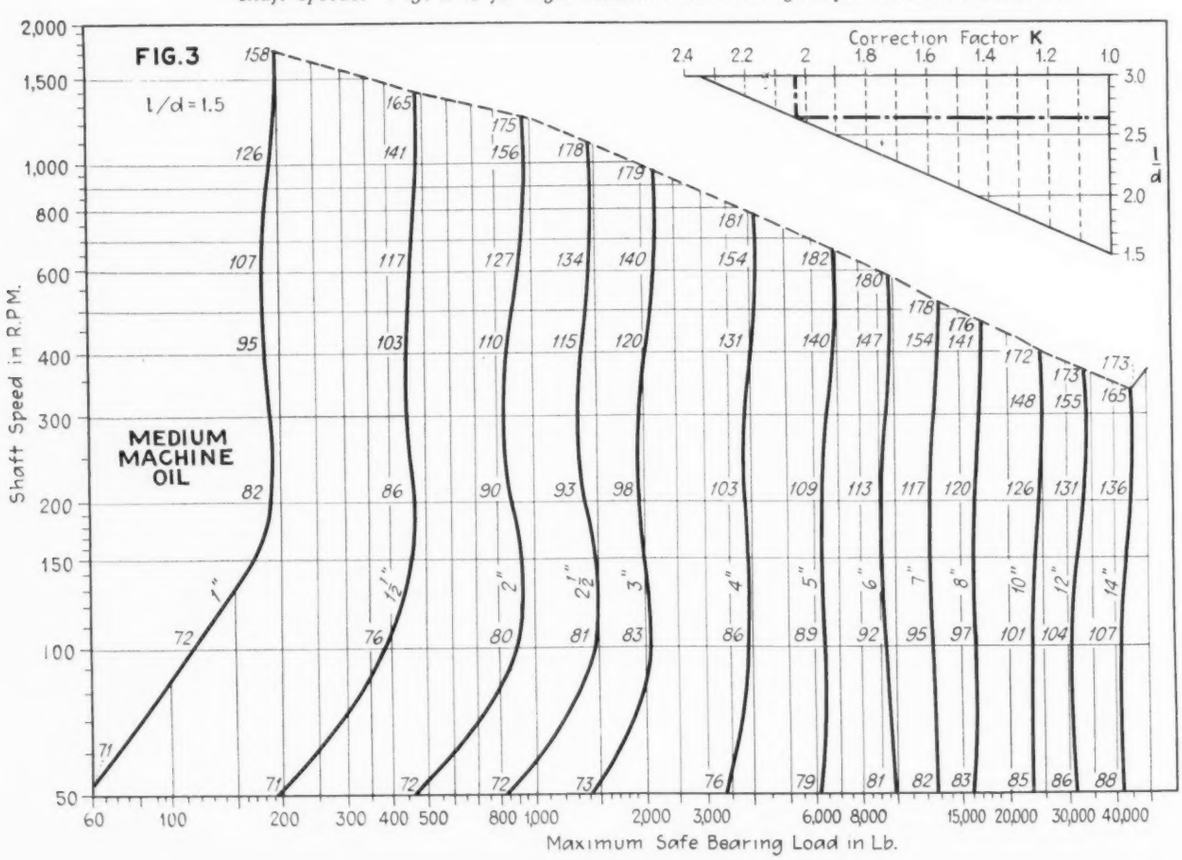
Correlating the rise of temperature and the frictional work done in the bearing, the curves in Fig. 1 show the work of friction F in ft.-lb. per sec. per sq.in. of projected area of the journal in terms of the temperature rise above 70 deg. F. Separate curves are given for non-ventilated, moderately ventilated, and well cooled bearings. Moderately ventilated bearings are subject to a current of about 100 to 200 ft. per min. For the well ventilated bearings, an air



Lubricant viscosity varies with the temperature as shown at the left for three grades of machine oil. The degree of cooling, in controlling the temperature rise, governs the friction loss as shown at the right



For shaft diameters from 1 to 14 in., oil temperatures are given for various loads and shaft speeds. Fig. 2 is for light machine oil and Fig. 3 for medium machine oil



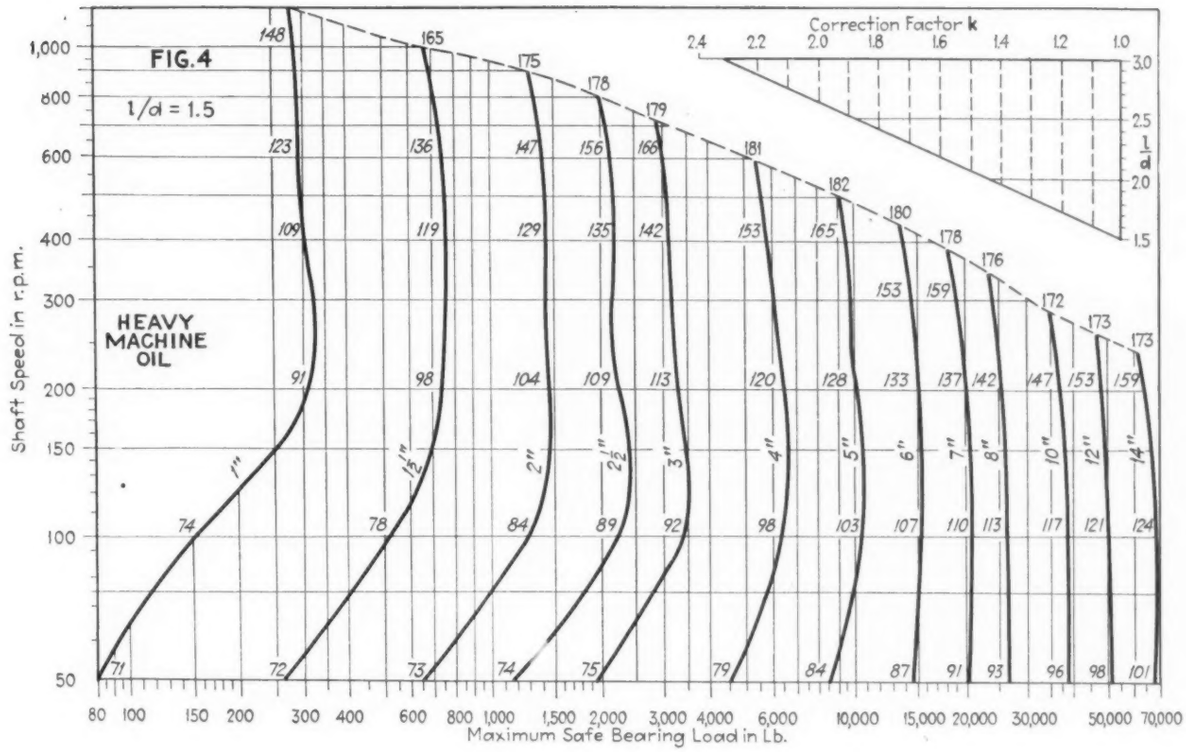


Fig. 4—Oil temperature and safe loads for bearings lubricated with heavy machine oil

blast of about 500 ft. per min. is assumed in the chart.

On the chart, Fig. 1, are curves giving the viscosity at the working temperature for three typical machine oils: light, medium and heavy. Viscosity V is given in centipose units, which can be converted from S.U.V. (Saybolt universal viscosimeter) readings by the relation:

$$V = 0.1974 \times density \times (S.U.V. - 8)$$

For a safe working load P in lb., on a shaft revolving at a speed of N r.p.m., the fundamental equations are:

$$N = 1.1 \times 10^6 \sqrt[4]{hS} \sqrt{\frac{F}{V}} \sqrt[4]{\frac{1 + l/d}{(l/d)^2 \, [4 \, (d/l)^2 + d/l]}}$$

$$P = \frac{NVd^4}{127 \times 10^6 \, hS} \times \frac{(l/d)^2}{1 + l/d}$$

In these equations d and l are the diameter and length of the journal, S is the average clearance between journal and bearing, and h is the thickness of the oil film, all dimensions in inches.

Charts plotted from these two equations are given in Figs. 2, 3 and 4, for non-ventilated bearings, surrounded by air at a temperature of 70 deg. F. Each chart is for either light, medium or heavy oil lubricant, separate curves on each chart designating journal diameters from 1 to 14 in. for bearings having a length of 1.5 d. Oil film temperatures are indicated for selected speeds by numbers placed over the curves. For example, Fig. 2 shows that when lubricated with light machine oil a bearing having a journal 5 in. in diameter and 7½ in. in length, rotating at 400 r.p.m., will carry a safe working load of 5,900 lb., the oil-film temperature being 134 deg. F.

These charts assume a bearing length of 1.5 d. To find the length of journal necessary to support a specified working load when the journal diameter and rotating speed are known, the chart values are modified by correction factors given in the auxiliary curve accompanying each chart. If the design calls for a bearing 5 in. in diameter rotating at 400 r.p.m. using medium machine oil, and, supporting a load of 13,600 lb., Fig. 3 gives a load of 6,700 lb. for a bearing length 1.5 times the diameter, or 7½ in. The ratio k of the desired load to the chart value is 13,600/6,700 or 2.03, the corresponding ratio of l/d as given in the auxiliary chart being 2.63. Then 2.63 d or 13 in. will be the length of the bearing.

For a bearing ventilated by a moderate air draft, the oil-film temperature will be lower than the values given in Figs. 2, 3 and 4, the viscosity higher and the safe working load will be greater. When F_o and F are friction losses for non-ventilated and ventilated bearings respectively, the viscosity V for the ventilated bearing is given by:

$$V = 0.5 \, (V_o + V_o F/F_o)$$

In this relation, V_o is the viscosity indicated by the oil film temperature in the charts. The safe working load for the non-ventilated bearing is corrected by the ratio of V/V_o to obtain the allowable load under ventilated conditions. But in adapting these chart values the ratio F_o/V_o should be approximately equal to F/V. If the ratio comes out too large, the assumed tempera-

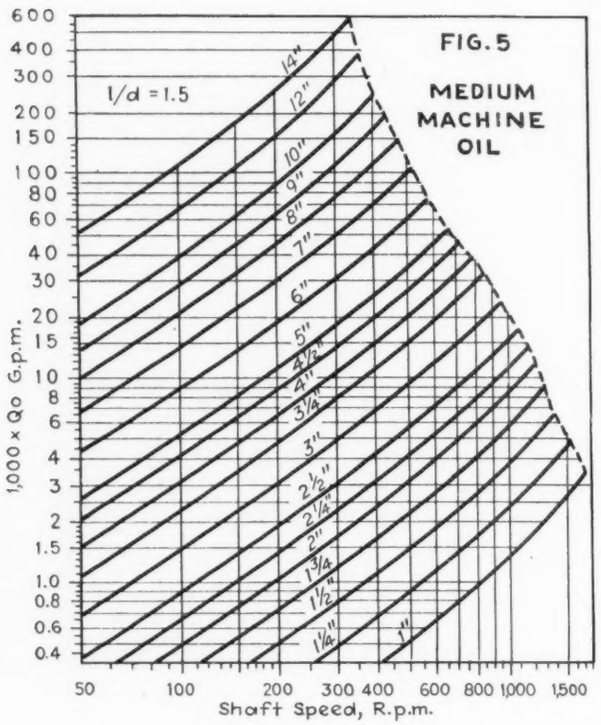


Fig. 5—Amount of medium machine oil escaping from the ends of the bearing for shafts from 1 to 14 in. in diameter and l/d ratio of 1.5

ture rise from Fig. 1 is increased to reduce the ratio.

An atmospheric or ambient temperature of 70 deg. F. is assumed in these charts. For lower air temperatures the load carrying capacity is not decreased, but higher air temperatures decrease the viscosity of the oil, thereby reducing the load capacity of the bearing. The decrease in oil viscosity with increased temperature can be obtained from the charts in the following manner: For a 5x7½ non-ventilated bearing rotating at 400 r.p.m. and lubricated with a medium machine oil, normal temperature service produces a bearing temperature of 140 deg., or a temperature rise of 70 deg. Under this condition, the maximum safe load is 6,700 lb. and Fig. 1 indicates an oil viscosity of 15.1 centipoise with 3.8 friction loss.

With the temperature of the air raised from 70 to 90 deg. F., the increased bearing temperature will be approximately ½ the increase in air temperature, or 10 deg., giving a bearing temperature of 150 deg. and a temperature rise of 60 deg. At this temperature the viscosity is 12.8, friction is 3.0 and the ratio V/F is 4.3, somewhat too large. Correcting the bearing temperature to 153 deg. the viscosity is then 12.7, friction is 3.1, and the ratio is 4.1, a more desirable value. The safe load at the elevated temperature is equal to the normal temperature load decreased by the ratio of the viscosities, that is, 6,700x12.68/15.1 or 5,630 lb.

The standard charts are constructed on a basis of American Standards Association standard running fits. The use of other standards will produce an appreciable difference in the allowable working load, the temperature of the oil and its viscosity. For example, the German "Din" standard for a 5x7½ in. journal, revolving at 400 r.p.m., calls for a clearance of 0.00315 in., while A.S.A. standards give 0.004 in. With the same speed and lubricant, the safe working load on the journal will be 9,900 lb., against 6,700 lb. obtained when using A.S.A. standards and the bearing temperature will be increased to 146 from 140 deg. F. With a journal 10x15 in. revolving at 300 r.p.m., the "Din" standard clearance of 0.00394 in. will support an allowable load of 55,800 lb. at a bearing temperature of 170 deg., compared with 25,000 lb. load and 148 deg. temperature when the A.S.A. standard clearances are used.

In reducing the length of bearings to lower their weight and cost of manufacture, and to make more accurate determination of bearing deflections, a shorter bearing allows more oil to escape through the bearing clearance, thus requiring a larger supply of lubricant. The minmum length of a bearing depends upon the lubricant selected.

The amount of medium machine oil escaping at the ends of a journal is shown in Fig. 5 for journal diameters from 1 to 14 in. assuming a ratio of 1.5 for l/d. These curves, based on the following equation, show the quantity of oil Q for a given bearing in terms of M, a practical coefficient ranging from 44,000 to 90,000.

$$Q = M \times \frac{P}{V} \times \frac{S^3}{l^2}$$

To find the amount of light machine oil supplied to a non-ventilated 5x10 in. bearing, revolving at 400 r.p.m., the intersection of the line for 400 r.p.m. with the curve for a diameter of 5 in. indicates a quantity of 0.025 gal. per min. But this bearing has a ratio of l/d of 2, instead of 1.5 assumed in the curve, and to correct for this difference, values of P and V must be found for bearings 7½ and 10 in. long.

From Fig. 3, the bearing temperature is 140 deg. F., the load is 6,700 lb., and the viscosity is 15.1 for a 5x7½ in. bearing. When using light machine oil for the bearing 10 in. long, the temperature becomes 134 deg., the viscosity is 13.3 and the bearing load is 5,900 lb. The quantity Q of lubricant required is corrected as follows, the subscripts referring to the bearing 7½ in. long.

$$Q = Q_o \times \frac{P}{P_o} \times \frac{V_o}{V} \times \frac{l_o^2}{l^2}$$

$$= 0.025 \times \frac{5900}{6700} \times \frac{15.1}{13.3} \times \frac{7.5^2}{10^2}$$

$$= 0.014 \text{ gal. per min.}$$

Power absorbed by friction in the oil film, in terms of the friction factor F from Fig. 1, is given by the following relation in which H is the power loss in horsepower.

$$H = Fld/550$$

To find the friction power absorbed by a 5x10 in. journal revolving at 400 r.p.m., assuming the bearing subjected to a moderate air draft and lubricated with medium oil, Fig. 3 gives 140 deg. F. for the oil temperature. The temperature rise is 70 deg. and the friction is 6.3 from the curve B in Fig. 1. Therefore, the power loss is 6.3x5x10/550 or 0.57 hp.

Free-Tumbler Gear Trains For Multiple Speeds

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THE use of the tumbler type of multiple-speed gear trains in machine tools is usually confined to screw cutting devices. Occasionally such gears are used for feed or or even main drives. It seems that few changes from the original form of this type of gear train, as shown in Fig. 1, have been attempted, although at least one manufacturer modified the form by substituting, as shown in Fig. 2, a short cone of gears in place of the single tumbler. The use of such compound tumblers in this general type of gear train has surprising possibilities in that a great number of speed ratios are obtainable.

In the development of the tumbler type gear train with compound tumblers, the first step is to arrange the two cones of gears so that each gear of one set can mesh with each gear of the other. This will lengthen out the construction materially, but the number of possible speeds will be increased quite a bit, there being twelve speed ratios in the form shown in Fig. 2. In this design there is danger of interference between a gear of one set and the shaft of the other set. In the arrangement shown, this might occur between *p* and *III* or between *z* and *II*, when *m* and *w* are in mesh. Nevertheless a good geometrical series of speeds can be obtained without getting into this difficulty if the ratio of consecutive speeds is not too far removed from unity.

The next stage of evolution is to build the train with a small cone of gears on each of the three shafts and arrange them so that each gear of the first group can mesh with each gear of the second group, and also that each gear of this second group can mesh with each gear of the third group. The expression free-tumbler has been coined to apply to this general type of gear train. The number of speeds increases tremendously, and if we can avoid the interference mentioned in the previous paragraph, it only remains for us to design a suitable means for positioning *II* relative to both *I* and *III*. Fig. 3 shows a possible arrangement for a 2-2-2 combination, with gears that will give a geometrical series of twelve speeds, with a ratio of consecutive speeds very close to $(2)\ \frac{1}{4} = 1.189$. The train values range from 1.00 to 0.15.

Referring to the figure, shaft *II* is carried on two compound links to maintain parallelism with the driver and the follower shafts. The latch operates two locking pins in each end of the free-tumbler shaft. These engage in suitably spaced holes in the end plates of the gear box. In setting the gears the procedure is as follows: Disengage shaft *II* by means of the latch and swing it out of the way to permit sliding the gear sets *I* and *III*. Then shift the two sliding gear sets of *I* and *III* and set their operating handles, which move

Fig. 1—The common tumbler type of gear train has only one cone of gears, a single gear being used for the tumbler and driven gear

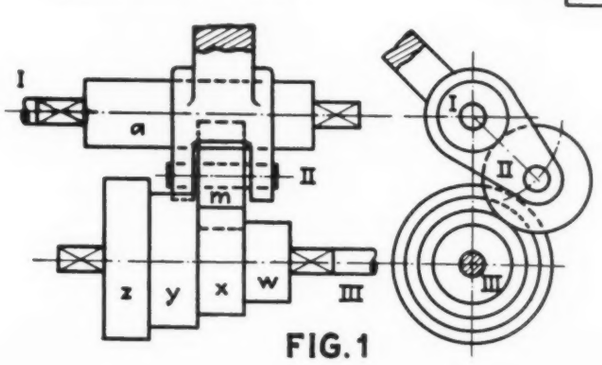


FIG. 1

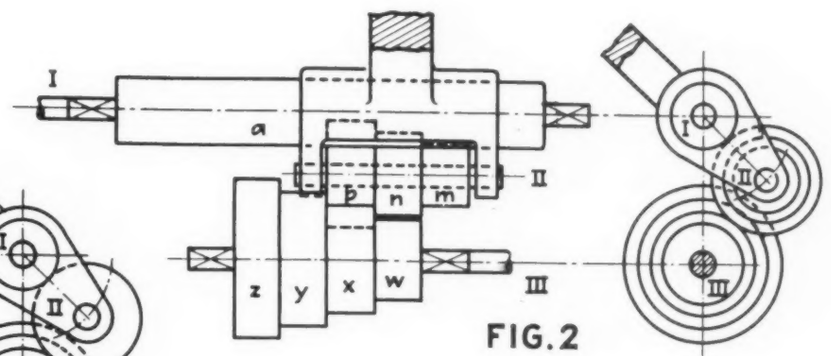


FIG. 2

Fig. 2—One modification of the common tumbler gear train is to use a short cone of gears in place of the single tumbler

over the speed plate fastened to the top of the box, to indicate the necessary positions for the desired speed. Finally, swing shaft *II* into position so that its gears engage a gear on each of the other shafts. The release of the latch pins into their holes will then set the two pairs of operating gears to the proper depth of engagement.

If the number of gears on each of the three shafts be represented by n_1, n_2, and n_3 respectively, the total possible number of speeds for any arrangement will be indicated by the following expression:

$$Speeds = (n_1 n_3)\ [1 + n_2 (n_2 - 1)]$$

In this equation $n_1 n_3$ equals the number of direct speeds when utilizing only one gear of *II* as a simple idler; and n_2 $(n_2 - 1)$ equals the number of free-tumbler type ratios and is numerically equal to twice the number of combinations of n_2 things taken two at a time. The secret of the large number of speeds obtainable is in the number of free-tumbler ratios.

The design of free-tumbler trains can be systematized. It can be indicated best by the following illustrative problem for a 2-2-2 combination to give twelve speeds in a geometrical series with a ratio of consecutive speeds of $r = (2)^{1/4} = 1.189$. If the range of speeds is to give as much of a speed reduction at one end as there will be an increase at the other end, the minimum speed will be $(2)^{-11/8} = 0.395$, and the maximum will be $(2)^{11/8} = 2.535$. The intermediate speeds will be all the odd powers of the eighth root of 2 from —11 to + 11, inclusive. There will be four speeds obtained directly, and eight obtained through the two free-tumbler ratios.

Let the gears on shaft *I* be represented by *a,b*, those on *II* by *m,n*, and those on *III* by *y,z*. Also, let the four direct ratios obtained by combining *a* and *b* with *z* and *y* be represented by R_1, R_2, R_3 and R_4 respectively; and let $n/m = r$.

If R_1/r be taken as the slowest speed, then $R_1 = (2)^{-9/8} = 0.458$. The third speed will be $R_1 \times r = (2)^{-7/8}$ and the fourth will be $R_2/r = (2)^{-5/8}$. Then $R_2 = (2)^{-3/8} = 0.771$. By a similar counting of consecutive speeds we finally see that $R_3 = (2)^{3/8} = 1.297 = 1/R_2$, and $R_4 = (2)^{9/8} = 2.181 = 1/R_1$. If the slide rule be set to the value of R_1 it will be found that the following pairs of values are close enough to the required ratio to warrant their possible use as the gears *a* and *z*: 12/26, 15/33, 16/35, 17/37, 21/46, 22/48, 23/50, etc. If the slide rule be next set to the value of R_2 the following values for *b* and *z*, having one of the *z*-values of the previous list, will be found: 20/26, 27/35, 37/48, etc. Finally set the slide rule to the value of R_4 and see if pairs of value can be found in which a previous *b*-value appears. These will be: 27/59, 37/81, and so forth.

Now set the slide rule to the free-tumbler ratio *r* and obtain these possible values for *m* and *n*: 19/16 24/20, 25/21, 31/26, 32/27, and so forth.

We might now use gears as follows: On shaft *I*, $a = 16$, $b = 27$; on shaft *II*, $m = 42$, $n = 50$; and on shaft *III*, $y = 35$, $z = 59$. The choice of the particular set of free-tumbler gears is determined merely by the need of avoiding interference.

The final stage of development is reached when the train is arranged to interchange shafts *I* and *III* so that either may be made the driver, while the other naturally becomes the follower. One method of accomplishing this is shown in Fig. 4, which is the 2-2-2 combination shown in the previous figure. The train values now range from 0.15 to 6.67 with a total of 23 speeds. In order to obtain the full number of 24 speeds, we must avoid duplicating the ratio of unity. The sample design just given could then be modified to have the lower set of 12 speed ratios range from $(2)^{-23/8}$ to $(2)^{-1/8}$, and by inversion the upper set of speed ratios would range from $(2)^{1/8}$ to $(2)^{23/8}$. It will be observed that no complicated calculations are involved, and that with this method the design of free-tumbler gear trains is a fairly straightforward procedure.

Fig. 3—An arrangement wherein two gears are used on each of the three shafts to give a geometrical series of 12 speed ratios ranging from 1 to 0.15

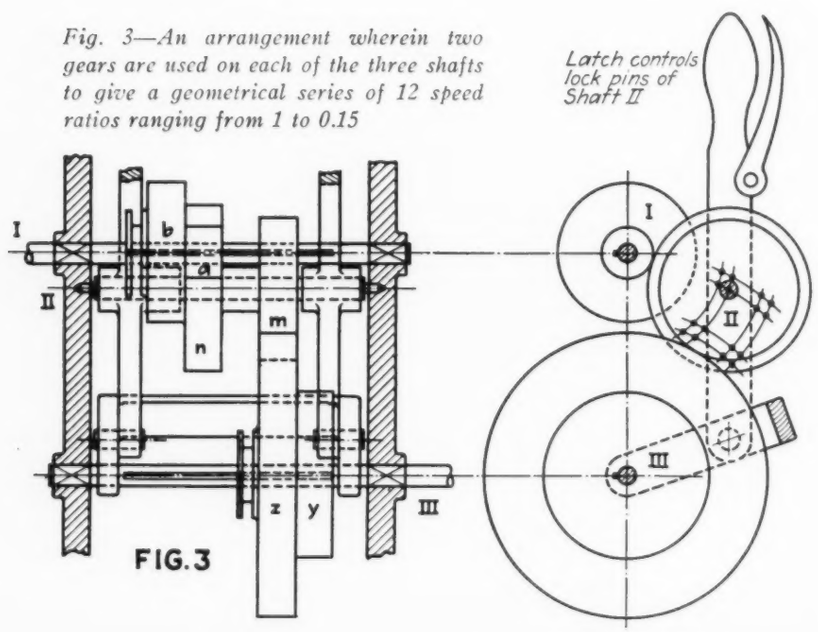


FIG.3

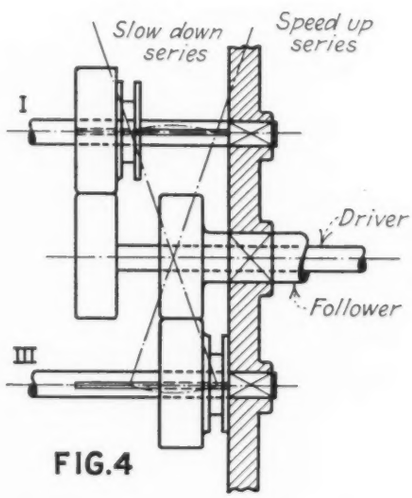
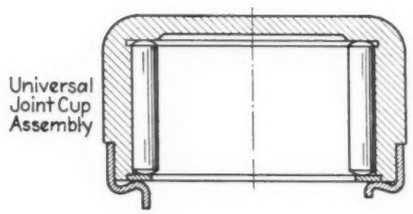


FIG.4

Fig. 4—The 2-2-2 combination shown in Fig. 3, rearranged to interchange shafts I and III, giving train values from 0.15 to 6.67, a total of 23 speeds

Needle Bearings
And Their Applications

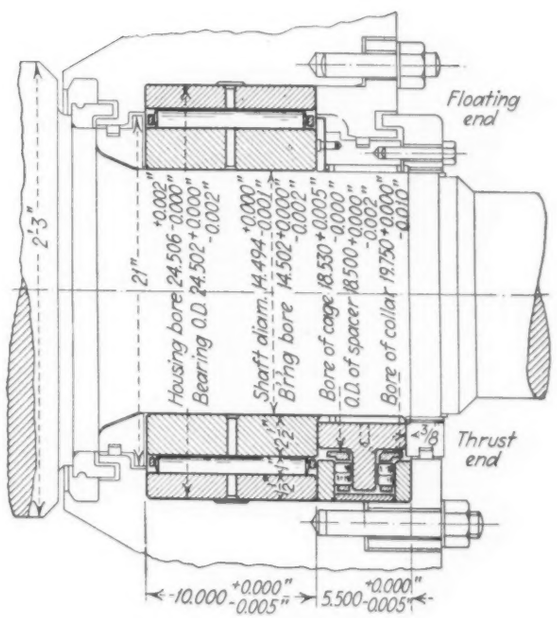


HERBERT CHASE
Consulting Engineer

Needle-type bearings are finding applications where a low-cost roller-type bearing is desired and where space restrictions require minimum diameters and relatively high load-carrying capacity

NEEDLE bearings are variously termed "quill" bearings, "full type roller bearings" "package bearings" and "needle bushings." For present purposes they may be defined as roller bearings wherein the rollers are fairly long in proportion to their diameter. Some forms of these bearings consist merely of rollers arranged to turn between shaft and housing without any races. Other types are furnished with either inner or outer race or both. In the less expensive forms having only an outer race, the rollers and outer race are case hardened, the race being of drawn carbon steel. With this construction it is recommended that the surface of the shaft in contact with the rollers, and really forming the inner race, be hardened and ground. A higher grade of needle bearing has through-hardened rollers, and, when races are furnished these are also through-hardened. At least one manufacturer is furnishing needle bearings with all parts made of stainless steel for applications such as washing machines and refrigerator compressors where high resistance to corrosion is important.

Perhaps the chief advantage of the needle bearing, aside from its low cost, is its compactness and high carrying capacity. It requires less space radially than other forms of anti-friction bearings and in some designs takes up no more room than a plain bronze bushing. Its carrying capacity, with through-hardened parts, however, is well above that of a plain bushing of the same



Bantam "Quill" bearings with a pair of roller thrust bearings, each having two rows of short rollers to take the thrust load at one end of the rolls of the machine

dimensions, and may be as much as 8,000 lb. per sq.in. of projected journal area.

Manufacture of rollers for needle bearings has been developed to a point where they are produced to sell for as little as one-tenth of a cent each in the small sizes. This is for a high-quality through-hardened roller in which the diameter on sizes $\frac{3}{32}$ in. and larger, is held within plus or minus 0.0001 in. limits, and plus or minus 0.0002 in. on rollers of smaller diameters.

To date, the most extensive use of needle bearings is in the automotive field but they are rapidly finding new applications in many other industries. The sizes of the journals range from a fraction of an inch up to at least $21\frac{1}{2}$ in. diameter. Although a considerable proportion

of the applications are for oscillating rather than for rotating bearings there are many of the latter and rotative speeds of 5,000 r.p.m. have been found feasible.

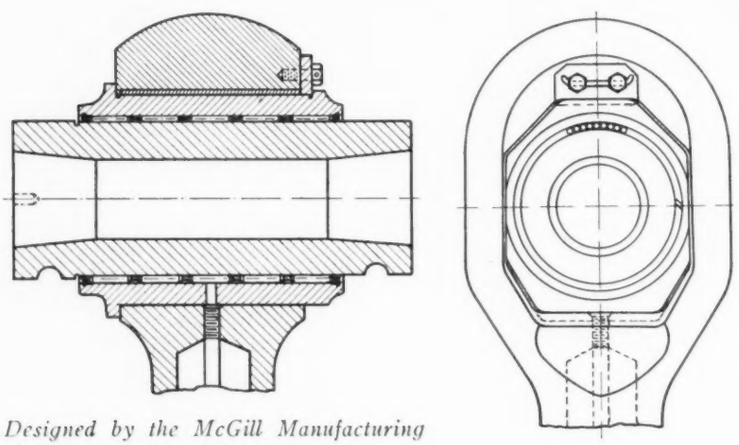
The initial automotive application of needle bearings was on universal joint trunions. Here the needle type proved so successful that it has virtually supplanted other types. Its compactness, low cost, ease of lubrication for life and ability to carry shock loads are all important favorable factors in this application.

Needle Bearing Applications

Needle bearings within transmission counter-shaft gears, where no separate races were needed and the space occupied was no greater than for bronze bushings, also proved successful. Today needle bearings are used also in the Dubonnet type of independent wheel suspension on Chevrolet and Pontiac cars, and on the joints of the Axleflex articulated front axle. They are used by Hudson, Terraplane and Nash; on the free-wheel pilot in Plymouth and Dodge cars; in Gemmer and Chrysler steering gears; and in certain truck transmissions put out by Spicer and Clark Equipment.

Experiments in the use of needle bearings on fan shafts, even when running in cast iron housings without races, are reported to be successful and likely of adoption in some 1935 cars. Other experiments in using similar bearings in the big ends of connecting rods are said to give promise, though involving certain problems yet to be solved.

Highly successful use of needle bearings is reported in the wrist pins of diesel engines of several makes and needle bearings are used as standard in Winton two-stroke cycle engines as supplied for the streamlined trains of the Burlington, Union Pacific and other railroads.



Designed by the McGill Manufacturing Company for converting a plain bearing piston pin for a large diesel engine to the use of a form of needle bearing having five rows of rollers

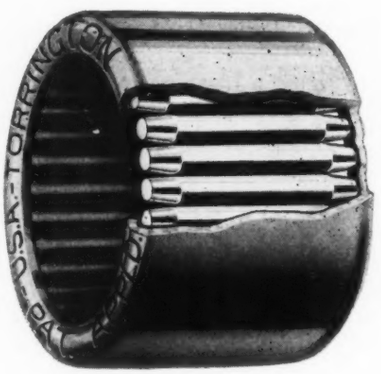
Tests of needle bearing equipped wrist pins for submarine and other diesel engines indicates their early adoption. Good results have also been obtained in pin mountings in caterpillar-type trucks.

In the steel mill equipment field, applications include cold mills, slitters and scrap cutters. A considerable number of applications have been made on various forms of machine tools for the metal-working industry. Electrical manufacturers employ needle bearings in electric ironers, vacuum cleaners, heavy-duty controller bearings and similar applications, and some use is made also on motor bearings and gear reducers in portable electric drills.

The latest Vultee transport plane made by the Airplane Development Corporation for American Airways employs needle bearings in fourteen locations, including wing flaps, transmission mounting for the retractable landing gear and in the tail-wheel mounting. Many other applications might be cited, but the above is indicative of the wide range of applications already attained.

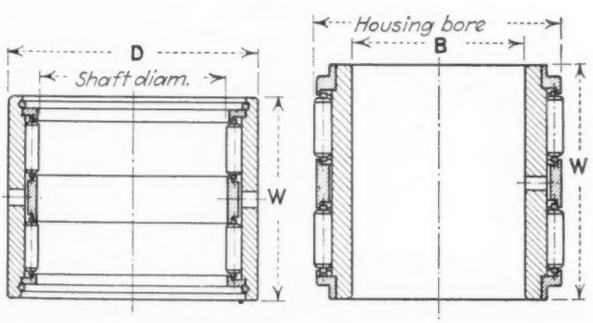
Since needle bearings are cylindrical, that is, not tapered, they have no thrust capacity, except for incidental shaft location in certain forms. When thrust loads must be carried, however, separate thrust rollers can be supplied or the bearings can be combined with ball thrust bearings or other types of bearings designed to take thrust loads.

Several different patterns of end finish for rollers are available, namely conical, chamfered, trunion, ball or



Form of "needle bushing" with drawn, case-hardened race spun over at each end to retain the rollers, making a complete unit, designed by The Torrington Company

Standard double-row full-type roller (needle) bearings as furnished complete with either inner or outer races (or both) by the McGill Manufacturing Company

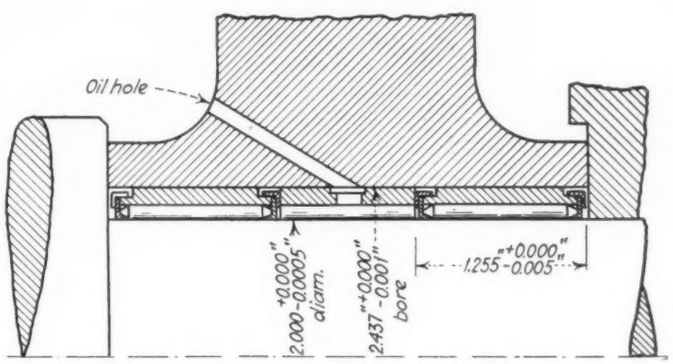


spherical. The last mentioned type is recommended for most uses, the radius of the end being equal to half the length of the roller. Roller diameters vary from $\frac{1}{16}$ in. up to $\frac{3}{4}$ in. or more, and lengths from about $\frac{1}{4}$ in. up to 8 in. or more. Trunion ends are used only when the rollers are held together by retainers to facilitate their assembly in the machine part in which they are used. When one or both races are supplied, a snap-ring arrangement can be provided to hold the rollers in place.

Multiple Rollers and Safe Loads

In the type of needle bushing made with a spun outer race, the race is turned inwardly to act as a retainer to keep the rollers in place, making a convenient cartridge-like assembly, which, when being mounted into a machine assembly, is handled substantially in the same manner as a bronze bushing. This form of bearing is available either with both ends open or with one end of the race closed or integral. In this latter design the outer race is a cup completely sealed at the outer end and intended, of course, only for use on the end of a shaft.

When the outside diameter of the bearing must be kept at a minimum and a single row of rollers is not adequate for the load without using rollers of excessive length in proportion to diameter, two or more rows of shorter rollers can be employed if properly spaced axially. As many as five rows of rollers are sometimes used. One maker of needle bearings recommended that for rotating bearings the length of the rollers be limited to six or eight times the diameter, as otherwise there may be a tendency for the rollers to jam. This is most likely to occur if an endwise load is applied, if the shaft or housing is deflected or if any taper exists in the bearing surfaces.



The Bantam Ball Bearing Company, makers of the needle type of bearing which it terms the "Quill" bearing and which has through-hardened rollers, computes the safe rated load R on the basis of the following formula:

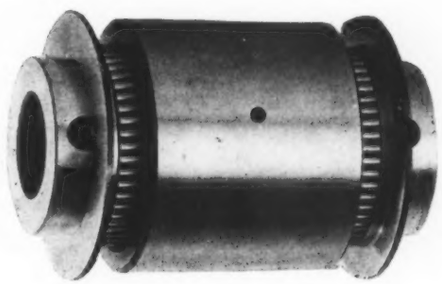
$$R = 31{,}416\,(D + d)\,L \div \sqrt[3]{S}$$

In this equation D is the diameter of the inner raceway which in some designs will be the journal diameter; d is the diameter of the rollers; L is the effective length of the rollers; and S is the r.p.m. of the rotating member. Dimensions, of course, are in inches, and R is the total rated load in pounds. For oscillating bearings, S may be taken as 8 r.p.m.

Outside the automotive field, the Northern Pump Company has supplied eccentric-ring heavy-duty pumps with the slipper shoes on the ends of the plungers mounted in needle bearings and with similar rollers between the body casting and the valve chamber around which it rotates. Loading on rollers is said to be 8,000 lb. per sq.in. of projected area.

Naturally, the allowable load carrying capacity falls off if the races are not as hard as the roller. Quill rollers are held within the range of 57 to 60, Rockwell C scale. Consequently, in computing carrying capacity when either race is softer than the roller, the right side of the above equation must be multiplied by a hardness factor. For hardness of 50 Rockwell C, the factor is 0.5 and for hardness 60 it is 1.0. It is not exactly a straight line relation, but can be considered as such within the range mentioned (50 to 60 Rockwell C) without introducing an appreciable error in determining maximum allowable loads for shafts within this range of hardness.

When needle bearings are applied without both races being supplied by the manufacturer, the recommendations of the latter as to clearances should be followed carefully.



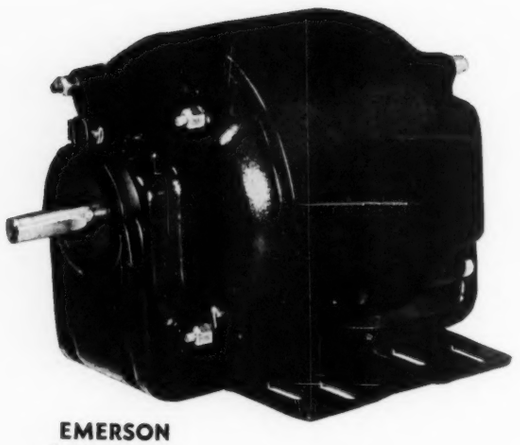
Reverse idler gear mounting, using a double row of Bantam "Quill" rollers running on a hardened shaft. (Left) Assembly of a Bantam "Quill" bearing for a piston pin on a marine Diesel engine

The method of lubrication applied in needle bearing varies with the type of application and the speed of rotation. For oscillating and some rotating bearings, packing grease is satisfactory, but it must be a non-corrosive grease which does not deteriorate in service.

If the closure is such that the grease cannot escape, such a lubricant may last for the life of the bearing. Oil lubrication is often used and need only be sufficient in quantity to keep the rollers wet. But for heavy loads or high speeds, forced circulation is sometimes advocated to help carry off excess heat. For speeds above 3,500 r.p.m. the quantity of oil fed may have to be limited to avoid excessive churning.

The lubricant, either oil or grease, can be fed to the bearing either through a hole in the shaft or a hole through the wall of the housing. Corresponding holes must of course be put in the inner or outer races.

Resilient Mountings

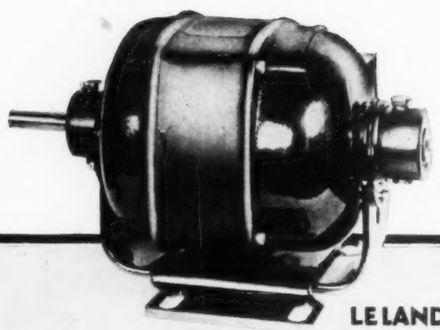


EMERSON
Rubber cradle

EXTENDED use of motor-driven equipment in the home, store and office, together with modern trends toward noise elimination, have led to the development of a variety of resilient motor mountings designed to reduce the transmission of sound and vibration. In the small single-phase motors shown on these pages special attention has been given to elimination of mechanical and magnetic noise at the source, as well as isolating the noise from the motor mounting.

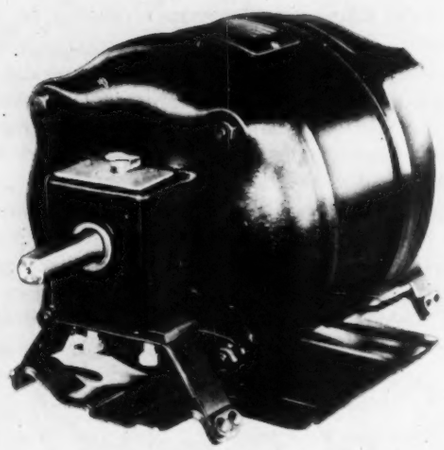
Mechanical noise has been reduced by careful design of bearings and centrifugal switches, and elimination of parts tending to act as vibrating surfaces. Special windings and improved magnetic circuits also have eliminated much of the magnetic hum. But some sound or vibration will occur in starting a motor, accelerating, running and stopping. To further silence the motor a form of noise and vibration isolation is needed. In each of the designs shown here, the motor frame is insulated from its base by rubber or spring mountings.

Resilient mountings to prevent the transmission of sound and vibration must be designed so that they will hold the shaft in the required alignment. Not all applications, however, require the same precision in alignment. For motors using V-belt drives or flat belts and idlers, alignment tolerances can be large, but the mounting must be designed to take side thrust caused



LELAND
Garter spring

DELCO
Vulcanized rubber



HOLTZER CABOT
Flat spring

To Avoid Noise

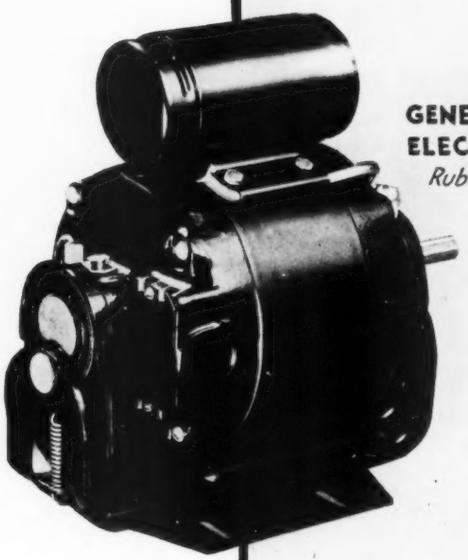
by belt tension. To maintain proper belt tension in some applications, spring-controlled belt tighteners are also needed. Direct connected motors requiring closer alignment have mounting designs—both rubber and spring types—which effectively absorb torsional vibrations and hold the shaft in close alignment.

Torque pulsations—the principal source of vibration—are always present in single-phase motors, the pulsations occurring at twice the frequency of the electrical current. Several types of rubber mountings, shown here, are designed to prevent these torsional vibrations from being transmitted to the appliance on which the motor is mounted. Rubber has the necessary mechanical strength and is highly efficient in absorbing both sound and vibration. Although the resiliency of rubber members is affected to some extent by light, heat and oil, recent developments in rubber and synthetic rubber compounds have decreased this tendency to age.

Steel springs in themselves are good conductors of sound, but they can be designed to dampen the transmission of sound and vibration, as illustrated by several designs shown here. Since vibration transmission is affected by the spring tension, resilience and stiffness, the spring suspension for each design is proportioned in accordance with actual operating conditions. In addition, the spring is shaped to cushion torsional vibrations and shocks in all directions.

OHIO
Rubber grommets

CENTURY
Rubber cushion



GENERAL ELECTRIC
Rubber

JANETTE
Spring

QUESTION AND COMMENT

Two Problems in Inserts

F. S. STICKNEY
Nutley, N. J.

● In the die-cast frame for an electrical instrument the design involved two unusual problems in inserts. First, it was necessary for the cylindrical core piece, shown in Fig. 1, to be of magnetic material. Second, the jewel bearing screw passing through the lower bridge had to be electrically insulated from the die-cast frame.

Most inserts in die-castings serve only to hold fastenings, being provided with holes or projections that can be used for locating these pieces in the die. But, in this casting, the core portion is required to be of steel, and this part has no holes or projections. In order to locate the steel core in the mold a brass stud is screwed into a threaded countersunk hole in the core. The stud is notched, so that the extension can be broken off before the die-casting is machined.

At the point where the stud is incased by the die-casting, as shown in Fig. 2, the threads lock the assembly together. Thus, the stud performs two functions: positions the assembly in the mold, and anchors the steel core to the die-casting.

One method of insulating the bearing screw in the lower bridge involves the use of two loose pieces and a nut on a shouldered screw as shown to the left in Fig. 3. However, as shown at the right, the use of an insert of phenolic material in the casting makes a less expensive construction, allows a reduction in overall dimensions and simplifies assembly operations.

Several problems are involved in the use of an organic material subject to decomposition at the temperature of molten zinc. By making the diameter of the insert large, leaving but a small section for the die-cast metal, the hot zinc when forced around the insert cools so quickly that no burning of the insert occurs.

To hold the insert in the molding die, a stem is provided to fit into a cavity in the die mold. After casting, the stem is readily broken off leaving only a thin disk of insulating material firmly locked by the encircling ring of zinc. To prevent the inser from turning, a V-groove is turned into the portion imbedded in the die-casting, the groove being squared in one section to act as a key.

Experience with larger zinc sections around the insulating material show that successful results can be obtained, provided the insert has no small projections of low thermal capacity. For heat insulation as well as electrical insulation handles for tools and household appliances can also be designed as inserts in die-castings.

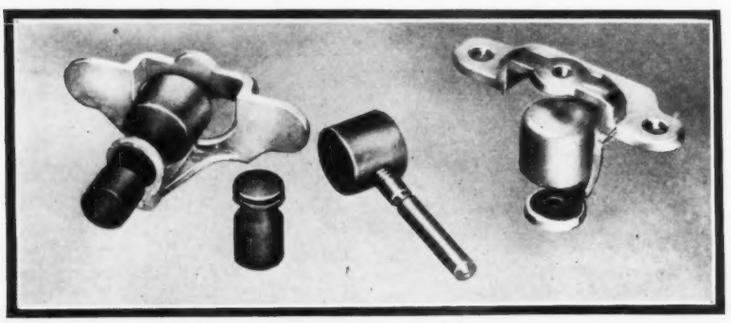


Fig. 1—Both phenolic and metal inserts are used in this die-cast frame for an electrical instrument

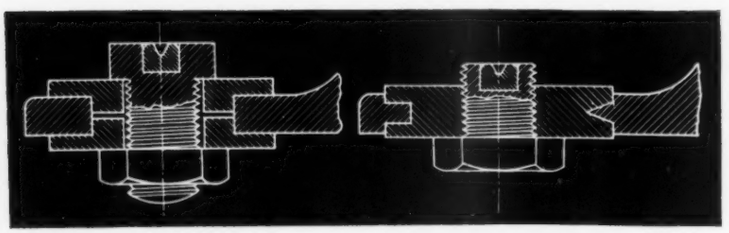


Fig. 3—Insert of insulating material makes possible fewer parts, smaller structure and lower assembly cost

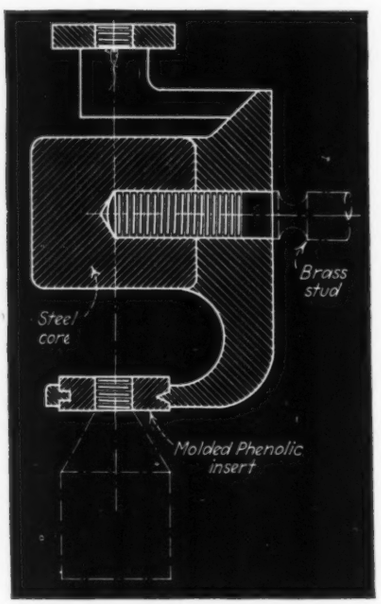


Fig. 2—Stems are provided for both inserts to position the parts in the die-casting mold. Notches allow the stems to be broken off before machining

Evolution of Business

To the Editor:

● Business, being of human origin, appears of necessity to go through the same process of evolution and to be subject to the same natural laws as human beings themselves.

There appear to be three stages in the evolution of business.

The first stage in the evolution of business is where it appears to be purely predatory, ruthlessly devouring all that comes in contact with it. In this stage of business the concern gains or benefits at the expense of its employees, customers, and the community, leaving everyone with whom it comes in contact worse off by grabbing more than it gives.

The second stage in the evolution of business is where the concern comes to realize that it does not pay to kill the goose that lays the golden egg, and tries to help its customer and employees, but still shows a ruthless disregard for the general public and the nation.

The third stage in the evolution of business is where the concern comes to realize that its welfare and the welfare of the nation and customers is an integral part of the welfare of the nation as a whole, and that its selfish interests can best be served by the advancement of the welfare alike of all with whom it comes in contact—its employees, its suppliers, its customers, and even its competitors.

Not until those who control the policy of the medium sized businesses of this country (constituting as they do, the major employing and purchasing power) truly reach this third stage of evolution, either through education or otherwise, will we be able to work our way out of the present difficulty and depression.

We must go off the gold standard in business, and substitute for it the human standard.

—J. Struthers Dunn
President, Struthers Dunn, Inc.

Design Papers Wanted

To the Editor:

● Since its organization, the Machine Design Committee of the A.S.M.E. has been making great efforts to procure suitable papers and speakers for meetings. There have been no dearth of papers submitted, but the trouble is that most of the papers dealt with specific special problems.

It cannot be expected that many engineers representing a great diversity of manufacturers would be interested in a paper that deals with a single specific product. To have general interest, the papers presented before the Machine Design Section meetings must relate to fundamental engineering problems, and treat the subject in a broad manner.

A good example of the type of paper desired is that which is scheduled for presentation at the annual meeting in December. This paper summarizes the design of sleeve-type bearings by the engineers of leading companies representing various industries. This summary is then analyzed in the light of generally accepted formulas and the peculiar requirements for the different applications.

As chairman of the Machine Design Committee of the A.S.M.E. I will appreciate it if you will call this to the attention of your readers and suggest to them that if they have any papers of the type desired, that they get in touch with me. We will also welcome any suggestions that might be made with reference to a subject that they might consider to be of value and interest for either annual or sectional meetings.

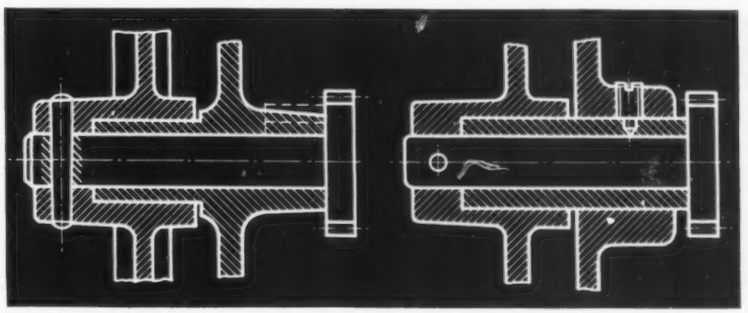
—James A. Hall
Brown University, Providence, R. I.

Single-Bearing Mountings

To the Editor:

● On analyzing their design and performance, single bearing mountings are subject to bell-mouthing because the pressure is not applied over the center of the bearing, but at a point overhanging from, or without, the bearing. This naturally causes the shaft to rock round the center point of the bearing, so producing the bell-mouthing, as explained by Hermann Hill in the May number, page 183. As with other forms of bell-mouthing, the cure consists in removing the point around which rocking takes places. While the arrangement shown by Mr. Hill in Fig. 2b might be suitable for a mechanism that does not operate continuously, it would not be rigid or durable enough for service in a continuously operating mechanism, such as a pump.

To the left, in the accompanying figure, the boss of the main casting forms a bearing for the pulley, the shaft receives very little load from the pulley, and the pressure from the pulley is applied at the center of the bearing area preventing any bell-mouthing tendency. The gear at the other end of the shaft can similarly be run on the main casting boss, as indicated by dotted lines at the right-hand side. With this arrangement, bearing speeds have increased but the bearing area has correspondingly increased.



In the design to the left, the boss of the main casting provides bearing surface. To the right, the pulley is mounted on a bushing in the main casting

It is not always convenient on a large casting to turn and face the bosses. Then it is often cheaper to use the arrangement shown at the right where the pulley is mounted on a bush fixed in the main casting. If the size of the gear permits, it may be mounted in the same manner as the pulley, with the pressure from it taken centrally by the bearing.

When both pulley and gear are mounted on the bosses the assembly is really a double bearing. When the connecting shaft has similar clearances to the other bearings, the assembly is particularly durable, for the loads are carried by the bearings of the pulley and the gear, and the shaft bearing. It is advisable to relieve the shaft in the center, to prevent rocking tendency from side pull of the belt.

—Harry Shaw

LOCATION OF CENTER OF GRAVITY AND AREA OF FILLETS

R	x	Area	R	x	Area	R	x	Area	R	x	Area
1/32	0.0069	0.0002	13/32	0.0901	0.0355	25/32	0.1733	0.1312	1 5/16	0.2911	0.3704
1/16	0.0139	0.0008	7/16	0.0970	0.0412	13/16	0.1802	0.1419	1 3/8	0.3050	0.4065
3/32	0.0208	0.0019	15/32	0.1040	0.0472	27/32	0.1871	0.1531	1 7/16	0.3188	0.4443
1/8	0.0277	0.0034	1/2	0.1109	0.0537	7/8	0.1941	0.1646	1 1/2	0.3327	0.4837
5/32	0.0347	0.0052	17/32	0.1178	0.0607	29/32	0.2010	0.1766	1 9/16	0.3466	0.5249
3/16	0.0416	0.0076	9/16	0.1248	0.0680	15/16	0.2079	0.1890	1 5/8	0.3604	0.5677
7/32	0.0485	0.0103	19/32	0.1317	0.0758	31/32	0.2149	0.2018	1 11/16	0.3743	0.6122
1/4	0.0554	0.0134	5/8	0.1386	0.0840	1	0.2218	0.2150	1 3/4	0.3881	0.6584
9/32	0.0624	0.0170	21/32	0.1456	0.0926	1 1/16	0.2357	0.2427	1 13/16	0.4020	0.7063
5/16	0.0693	0.0210	11/16	0.1525	0.1016	1 1/8	0.2495	0.2721	1 7/8	0.4159	0.7559
11/32	0.0762	0.0254	23/32	0.1594	0.1111	1 3/16	0.2634	0.3032	1 15/16	0.4297	0.8071
3/8	0.0832	0.0302	3/4	0.1663	0.1209	1 1/4	0.2772	0.3359	2	0.4436	0.8600

Fillet Tables

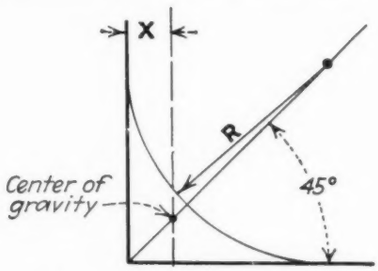
W. F. BRECHT
Chief Engineer, Van Doren & Rideout

● Although tables of fillet areas are common, the location of the center of gravity is often needed in connection with welded structures and the design of containers with rounded corners.

The accompanying table gives both fillet area and location of center of gravity using the following relations:

$$Area = 0.215\ R^2$$
$$X = 0.2218\ R$$

Dimension X, shown in the accompanying figure, is the distance of the center of gravity from the fillet tangent.



Values of X for various fillet radii are given in the table

Grain Size in Steel

HOWARD SCOTT
Metallurgist
Westinghouse Research Laboratories

● An "inherently fine-grained" steel is distinguished primarily by the fact that it has a high coarsening temperature; that is, a higher temperature is required to produce a coarse grain than in an "inherently coarse-grained" steel.

Although the tensile strength and yield point of steel does not appear to bear any relation to grain size, a coarse-grained steel has slightly lower tensile elongation and markedly lower reduction in area than a fine-grained steel. The most prominent effect of grain size is on the toughness of hardened steels. The difference in impact resistance is very large and in favor of the fine-grained steel.

For steel in the normalized condition, however, grain size has much less significance. A coarse-grained steel is somewhat harder and less ductile, but the differences are possible due to composition differences alone within the specification range.

Steels machine better in the coarse-grained condition but in the fine-grained type the temperature required to produce a coarse grain is excessively high. Certain steels, however, will coarsen at an intermediate temperature and are preferable for use where high machinability as well as toughness after hardening are important requirements.

A high coarsening temperature makes possible the consistent attainment of a fine grain size in a heat treated steel without extreme precautions in heat treatment. There is less danger of overheating protruding sections and carburized steel can be quenched from the pot without embrittlement. These are real advantages. The major objectionable characteristic of high coarsening steel is less penetration of hardening but this is easily corrected by a slight increase in manganese content.

Tables Wanted

To the Editor:

● Tables of weights in pounds and fractions for a given number of pieces when the number of pieces per pound is known would be useful in many lines of design work. For example, suppose that 675 pieces weigh 1 lb. If 128,000 pieces are needed, what would be their total weight? Are tables available giving these data?

—E. BLOCK

The Industrial Designer

To the Editor:

● I am afraid that the article in the October issue of *Product Engineering* on the redesign of the American Sales Book Company's autographic register gives me too much credit, or rather places too heavy a load of responsibility on my shoulders.

It is the designer's business to work with established conditions and involve his client in as little expense as possible. Internal mechanisms should determine housings: housings should not determine the design of internal mechanisms. My purpose in designing the autographic register was to simplify production to the ultimate degree, and I believe it succeeded in doing exactly that.

The revision of the mechanism of this register was a part of the American Sales Book Company's original plan, decided upon before they retained my services. They wanted to modernize the device both from the mechanical point of view and from the standpoint of appearance. To satisfy both of these factors, mechanical design and improved appearance, it was decided to scrap all tools and start from a fresh beginning. Here I entered the picture.

It was my obligation to design the housing which should be attractive, modern and simple, and at the same time, easy and economical to manufacture and assemble. To Pack-Morin was entrusted the redesign of the internal mechanism, and this was accomplished with great success.

—WALTER TEAGUE

Dynamic Loads on Gear Teeth

To the Editor:

● Recommended Practice of the American Gear Manufacturing Association as given in the article "Load-Carrying Ability of Metal Spur Gears," on page 223 of the June number of *Product Engineering* includes the following formula: $W_d =$

$$\frac{.05PLV \times (FW \times C + W)}{.05PLV + \sqrt{FW \times C + W}} + W \qquad (1)$$

W_d = total dynamic load, lb.
FW = face width of gear, inches
W = 33,000 x hp./PLV = static tooth load
PLV = ft. per min. pitch line velocity
C = deformation constant from the table given in the article

From the A.S.M.E. Report on Dynamic Loads on Gear Teeth,

$$W_d = FW\left(\frac{W}{FW} + I\right) \qquad (2)$$

The factor I in this relation is:

$$I = \frac{0.05 \times PLV \times \left(\frac{W}{FW} + C\right)}{0.05 \times PLV + \sqrt{\frac{W}{FW} + C}} \qquad (3)$$

Substituting I from Equation (3) in Equation (2),

$$W_d = FW \times I + W$$

$$= FW \times \frac{0.05 \times PLV \times \left(\frac{W}{FW} + C\right)}{0.05 \times PLV + \sqrt{\frac{W}{FW} + C}} + W \qquad (4)$$

Dynamic loads calculated from these two formulas differ widely. For example, the A.G.M.A. relation, Equation (1) indicates that a gear with a face width of 3 in., running at 367 ft. per min. carrying a load of 3,000 lb., is subject to a dynamic load of:

$$\frac{.05 \times 367 \times (3 \times 2500 + 3000)}{.05 \times 367 + \sqrt{3 \times 2500 + 3000}} + 3{,}000$$

$$= 4{,}600 \text{ lb.}$$

By Equation (4) based on the A.S.M.E. formula a much larger dynamic load is obtained:

$$3 \times \frac{.05 \times 367 \times \left(\frac{3000}{3} + 2500\right)}{.05 \times 367 + \sqrt{\frac{3000}{3} + 2500}} + 3{,}000$$

$$= 5{,}490 \text{ lb.}$$

Undoubtedly there has been some mistake made in developing the formula given by the A.G.M.A. Recommended Practice.

—A. C. RASMUSSEN
Insley Manufacturing Company

Correcting Power Factor

To the Editor:

● Under the title "Modernized Design for Group Drives Will Open Wider Markets," the editorial in the August number outlines the activities of the Mechanical Power Engineering Associates. The difficulty seems to be that leather belt manufacturers were absorbed for so many years in reaping a bountiful harvest, that they gave little thought to competition. New methods of power transmission and new types of efficient drives long ago eliminated group drives in favor of short-center V-belts, silent and direct-connected drives.

Power factor correction is one of the advantages given for group drives, but only in rare instances will power factor be improved. If only one machine out of four in a group drive is operating, the group-drive motor produces far more "wattless" current than an individual-drive motor.

In order to allow for a factor of safety for safe performance, motors are always slightly underrated. The machine designer, not knowing exactly under what condition the machine may operate, adds his factor of safety in selecting a motor for a given drive. This excess capacity built into the motor penalizes the machine operator by reducing the power factor.

In any motor drive, power factor can be improved by selecting a motor from consideration of the actual horsepower or torque required for starting, the actual horsepower at no-load and at full-load, and the starting equipment used. The torque required to start a machine can be readily determined by pull from a spring scale attached to a lever on the main drive shaft. No-load and full-load power can be determined by the use of a calibrated motor as a temporary drive, measuring the motor current.

With these conditions accurately determined motors can be selected for each drive on the basis of from 3 to 8 per cent overload, making possible a considerable reduction in power factor losses. Better results in power-factor correction can be obtained through better field work and more accurate investigation, rather than by the application of group drive.

—L. A. CORWIN
Chief Engineer
Milwaukee Chair Company

Drawing and Pattern Symbols

H. L. WYNN
Executive Engineer
Pacific Electric Mfg. Corporation

● Occasionally, most of us wonder why we do things in certain ways. Perhaps our methods are based not particularly upon reason but just because we have accepted the facts as presented without giving any thought as to whether they could be improved upon. One of the subjects that can be justly classified under this category is the numbering of drawings and patterns.

It certainly appears that the present trend is towards a combination of letters and numerals that are the zenith on complicacy. This condition can best be attributed to the tendency on the part of those responsible to safeguard those instruments that are traditional in character. In many cases, otherwise clear-cut issues are held in abeyance only because they are too revolutionary. However, in the last analysis, it would appear unethical to the average mind to be burdened with a system that has nothing more basic than the fact that it has always been used and, therefore, why bother to make a change at this late date.

It is entirely obvious that many enterprises are using a medium for the numbering of their drawings and patterns that is antiquated. It is not particularly that their drawing numbers are complicated but they have added to the confusion by giving patterns made from these details a different identification. It should seem more reasonable to have the pattern number the same as its drawing.

This can be accomplished by giving each of the various sizes of drawings a prefix, either a letter or a numeral, but preferably a letter. It is customary to start each under its own set of numbers commencing with, one. An illustration would be thus: A-1 or L-1. After the first week there will be very little difficulty for as a rule the individual details are far in excess of those of any other class. This situation will permit the various numbers to rapidly drift apart from each other. It will be immediately apparent that the pattern will carry exactly the same designation as the drawings from which they were made. In this way we have a perfect coordination between these elements with the result that drawing and pattern indexing is correlated and at the same time tremendously simplified.

Another factor that might be overlooked is that the stock records disclose not a multiplicity of mythical amalgamations but a set of identifying symbols that are immediately intelligible to all departments within an organization. This proposal is not the last word, but it is simple and effective and will function with the least amount of effort. Often it is a good thing to focus a beam of inquiring light on such activities—it may reveal cobwebs.

Eight Types of Retaining

This concluding article illustrates clamping plugs, wire locks,

ADAM FREDERICKS

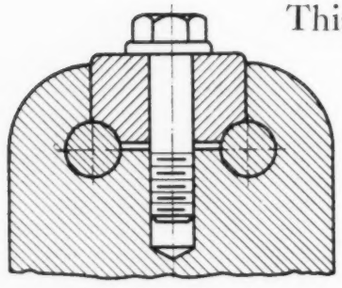


FIG. 73

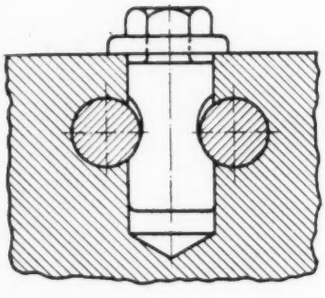


FIG. 74

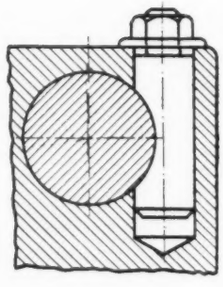


FIG. 75

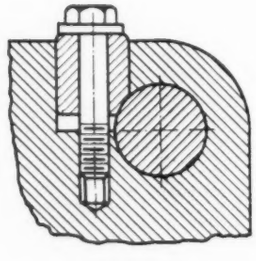


FIG. 78

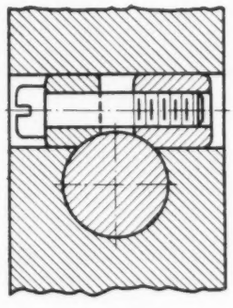


FIG. 76

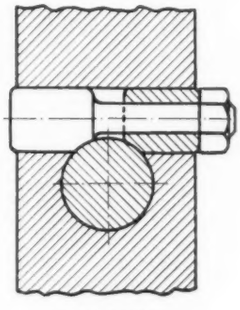


FIG. 77

Figs. 73 to 78—Round bars may be held singly or in multiple with one or two-piece formed plugs and clamped either with screw or nut and washer. Clamping plugs may be reamed in place for accurate contact with round pieces.

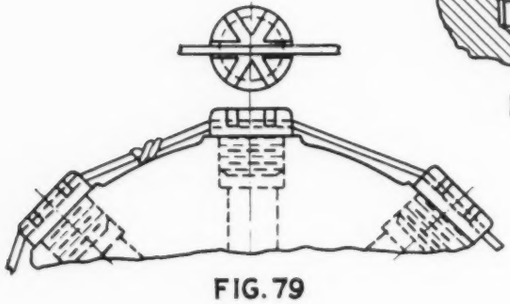
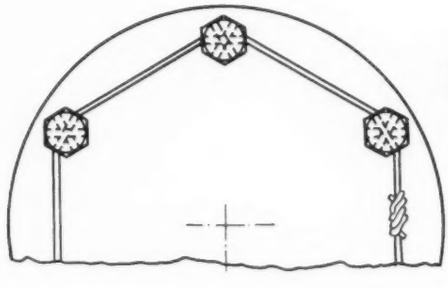


FIG. 79

Figs. 78 to 82 — Soft flexible wire that withstands twisting offers an efficient retention of either slotted or drilled screws. Fig. 80 presents a method used extensively in automobile rear axle design.



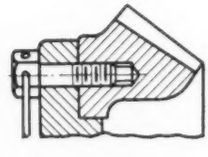


FIG. 80

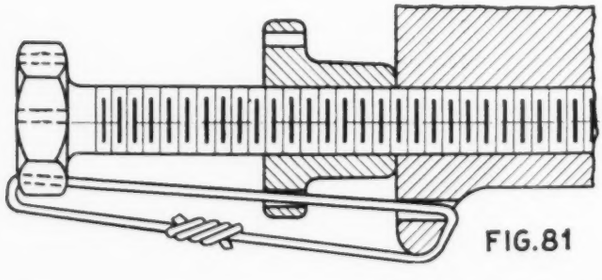


FIG. 81

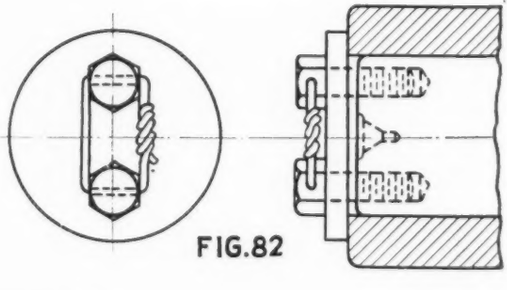


FIG. 82

and Locking Devices—IV

pin retainers and other miscellaneous holding arrangements

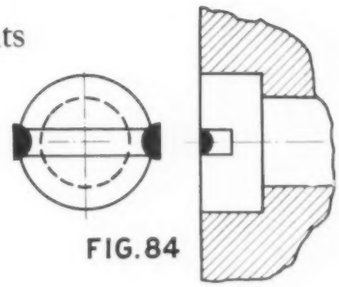


FIG. 84

Fig. 83 — Combination of screw and taper pin *A* bind projection *B*. Fig. 84—Metal peened into screw slot prevents rotating. Fig. 85—A hollow head fillister screw engages groove in wedge, clamping projection *A*. Fig. 86—Shafts coupled and securely clamped by wedge headed screw and nut. End view shows special head.

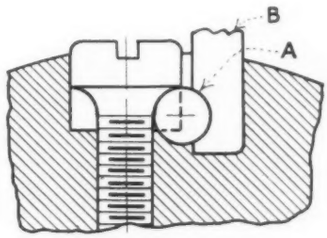


FIG. 83

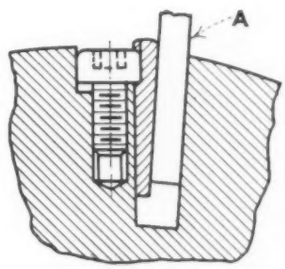


FIG. 85

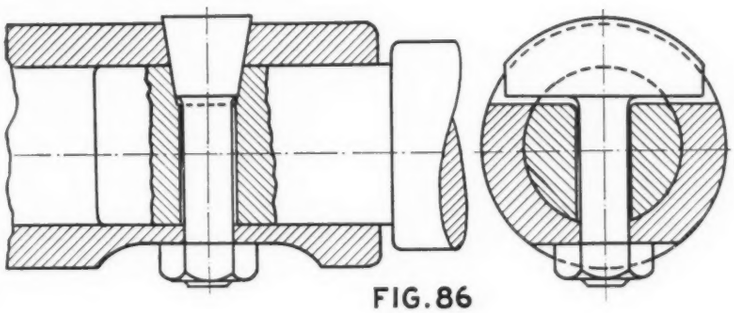


FIG. 86

FIG. 87

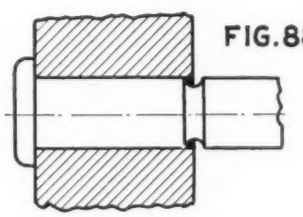


FIG. 88

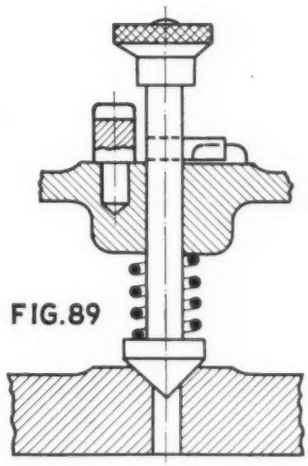


FIG. 89

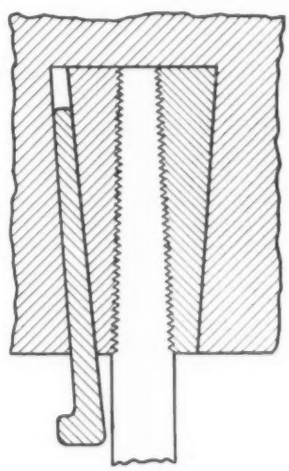


FIG. 90

FIG. 91

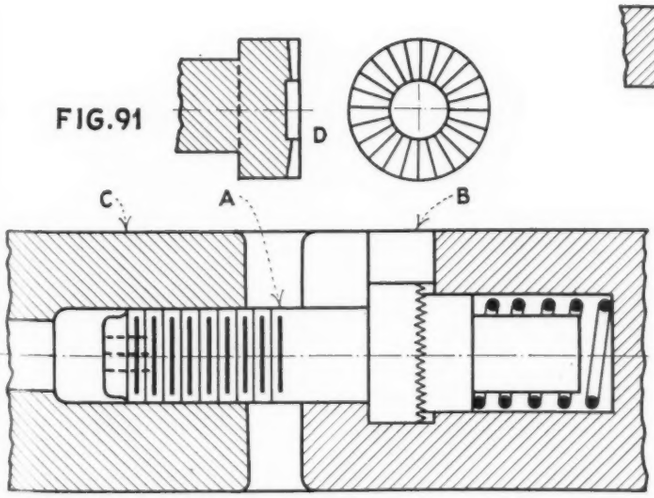


Fig. 87—Bayonet joint. Fig. 88—Hole edge peened into stud groove. Fig. 89—Valve kept open by lifting and turning 180 deg. Fig. 90—Board in drop hammer held by toothed wedges and steel driving wedge. Fig. 91—Serrated head of screw *A* in groove *B*, engaging spring backed plug, locks shaft *C* against endwise motion. Serrations shown at *D*.

NEWS

Acetylene Men Hold Annual Convention

PAPERS covering all phases of gas welding and cutting, including one on courses in welding for technical schools, were presented at the 35th Annual Convention of the International Acetylene Association held at Pittsburgh, Pa., on November 14-16. One of the high-lights of the convention was a play held at the Davis Theatre dramatizing the expected development of still lighter high-speed diesel engines for railroad service. After filling the hall to capacity and allowing about 100 standees, it was found necessary to turn away a crowd estimated at 200 people.

In a comprehensive paper, James W. Owens, director of the National Weld Testing Bureau, summarized the commercial methods of testing welds and commented on the dependability of such methods. He recommended for "pre-construction tests" of fillet welds, the fracture and transverse shear tests, and for butt welds the nick-break, full section tension, reduced section tension, face free bend and free bend tests.

For construction tests Mr. Owen recommended the same tests as those for pre-construction with the addition of the chipping test for fillet welds, and for butt welds the addition of the radiograph, all weld-metal tension, specific gravity and chipping tests. Recommended proof tests included radiographing all joints, hydrostatic testing, and hammer shock testing with the product under hydrostatic pressure.

The paper also included typical clauses for purchase specifications for fusion welded products.

Other papers included "What the Young Engineer Should Know About Welding," by Robert L. Spencer, dean of the School of Engineering, University of Delaware; "Metallurgy of Oxy-Acetylene Welding" by J. H. Critchett, vice-president of Union Carbide and Carbon Research Laboratories, Inc.; "Hard-Facing—The Application of Wear-Resistant Alloys to Steel Mill Equipment," by E. E. Le Van of Haynes Stellite Company; "Gas Welding of Aluminum Tanks," by G. O. Hoglund of the Aluminum Company of America; and "Advantages of Flame Cut Surfaces for Welding," by C. W. Obert, honorary secretary of the boiler code committee of the A.S.M.E.

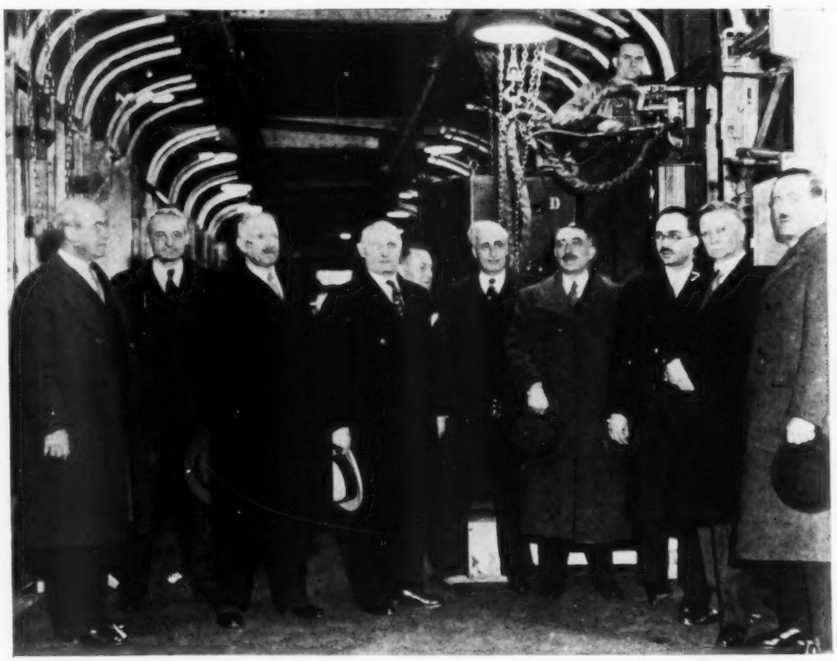
French Delegation Inspects Rail Cars

ON November 12 a group of prominent French engineers representing the French railroads visited the plant of the E. G. Budd Manufacturing Company at Philadelphia to view the latest developments in the construction of light-weight, high-speed railroad trains. The group of visiting engineers was headed by Louis Baticle, Director of (French) Railroads under the Minister of Public Works.

Special interest was shown by the visitors in the Budd company's use of light-weight stainless steel in car construction and in the shot-welding process for fabricating the steel.

In explaining the object of their visit, M. Baticle stated that the French engineers had come to this country to study recent railway developments from both the operating and construction angle, with a view to their possible application in France. The problems of railway passenger traffic and the measures being taken here to meet the effects of the depression, together with effects of bus and passenger car competition, are of particular interest to his group, he said, since these factors also vitally affect the French railways.

Other members of the visiting delegation included Lucien Dumas, chief engineer of Chemin de Fer du Nord; Emile Pellarin, assistant director of the Chemin de Fer de l'Est; Charles Epinay, chief engineer of the Chemin de Fer Paris, Orleans et Midi; Victor Nicollet, chief engineer of the Chemin de Fer de l'Etat; Jean Walter, engineer of the Chemin de Fer de l'Etat; Hubert Lejeune, representative of the French State Railways located in New York.



Visiting French delegates in the rail-car shop of the Budd Manufacturing Company. Reading from left to right the photograph shows F. H. Russell and A. H. Ehle of the Budd Company; Emile Pellarin, Louis Baticle, Pierre Abbat, Filipo Schiaffino, Charles Epinay, Jean Walter, Edward G. Budd and P. G. Van de Velde, manager of the Budd company's French office

Leipzig Fair Adds Inventors' Exhibit

DESPITE the depression, the number of inventions is increasing in the great producing countries. To encourage inventive genius a special exhibition of new inventions which is open to all nations has been made a permanent feature of the Leipzig Trade Fair. Special attention will be given to all inventions and novelties which have not been exploited industrially.

Proposed Standard For Gages

A PROPOSED American Standard for pressure and vacuum gages for standardizing gage sizes, mounting dimensions, size and type of connections of gages and cocks, indicator hands and stop pins, has recently been completed by Subcommittee 3 of the Sectional Committee on the Standardization of Pressure and Vacuum Gages.

Other proposed standard specifications include: The flanges of all gages are to have three mounting holes 120 deg. apart with one hole on the vertical center line at top; wall mounted gages may be either bottom or back connected; flush mounted gages are to be back connected; bottom connections are to be male; back connections are to be female with the exception of the 2 in. size which is to have male connections; for pressures up to 1,000 lb. per sq.in., ¼ in. connections are to be used with the exception of the back-connected 2 in. size which is to have ⅛ in. connections; for pressures over 1,000 lb. per sq.in., ½ in. connections are to be used; the taper of the pinion shaft is to be 0.50 in. per ft.; stop pins are to be placed at the beginning of the scale of all gages except test and pressure vacuum gages, so that the pointers come to rest on zero.

Criticism and comment on these proposed specifications will be welcomed by the committee and should be addressed to C. B. LePage, assistant secretary, The American Society of Mechanical Engineers, 29 W. 39th Street, New York, N. Y.

Design Sessions Scheduled at A.S.M.E. Annual Meeting

GREATER recognition of the needs of the designer is found in the program for the annual meeting of the American Society of Mechanical Engineers being held December 4, 5 and 6, in New York. In two sessions devoted to bearing problems, important data for the design of bearings will be presented. The second session will be given entirely to a paper by H. A. S. Haworth of the Kingsbury Machine Works on "Current Practice in Pressures, Speeds, Clearances and Lubrication of Oil Film Bearings."

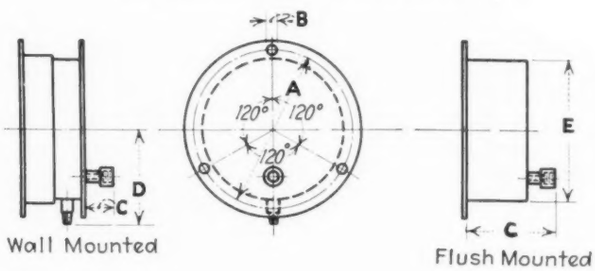
Mr. Haworth's paper represents a great forward step in bringing together actual design information from many fields. Tables prepared for this meeting present the practice of leading companies in the design of bearings for such diversified equipment as turbines, punch presses, textile machinery, machine tools, and steel mill machinery. This paper offers no comments in regard to the variations disclosed in the practice of various companies, but only presents the results of the survey. Explanations for the divergence between the practices used in many successful designs will undoubtedly point the way toward greater standardization in the design of journal bearings.

Other A.S.M.E. sessions include one on the use of alloy steels in the design of railroad equipment. A session sponsored by the Applied Mechanics Division includes papers by F. A. Mickle and F. L. Everett on "Stress Analysis of Failures in Machine Parts," one by R. E. Peterson and A. M. Wahl on "Fatigue of Shafts at Fitted Members," and a paper, "Pitting of Metallic Surfaces Due to Rolling Contact," by Stewart Way.

Also scheduled are sessions on vibrations and mechanical springs.

Mounting Dimensions for Pressure and Vacuum Gages

All Dimensions Are Given in Inches



Size of Gage	Diameter of Bolt Circle Dimension A	Size of Holes Dimension B	Dimension C				Dimension D		Dimension E
			Wall Mounted Gages		Flush Mounted Gages				
			Min.	Max.	Min.	Max.	Min.	Max.	Max.
2	.....	.....	3/8	7/8	.....	.....	1-1/2	2	2-1/4
2-1/2	3-1/8	5/32	3/8	7/8	1-1/2	2	1-3/4	2-1/4	2-3/4
3-1/2	4-1/4	5/32	3/8	7/8	1-3/4	2-1/4	2-1/4	2-3/4	3-3/4
4-1/2	5-3/8	7/32	3/8	7/8	2	2-1/2	2-3/4	3-1/4	4-3/4
5	5-7/8	7/32	3/8	7/8	2	2-1/2	3	3-1/2	5-1/4
6	7	9/32	3/8	7/8	2-1/4	2-3/4	3-1/2	4	6-1/4
8-1/2	9-5/8	9/32	3/8	7/8	2-1/4	2-3/4	4-3/4	5-1/4	8-3/4
10	11-1/4	9/32	3/8	7/8	2-1/4	2-3/4	5-1/2	6	10-1/4
12	13-1/2	9/32	3/8	7/8	2-1/4	2-3/4	6-1/2	7	12-1/4

MEETINGS

American Society of Mechanical Engineers—Annual meeting, Engineering Societies Bldg., New York, N. Y., Dec. 4-6. C. E. Davies, executive secretary, 29 West 39th St., New York, N. Y.

Society of Automotive Engineers—Annual meeting, Book-Cadillac Hotel, Detroit, Mich., Jan. 14-18. John A. C. Warner, secretary, 29 West 39th St., New York, N. Y.

American Institute of Electrical Engineers—Annual meeting, Engineering Societies Bldg., New York, N. Y., Jan. 22-25. H. H. Henline, secretary, 33 West 39th St., New York, N. Y.

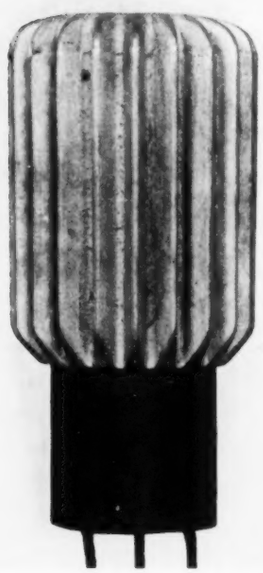
EXHIBITIONS

Power Show—11th National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York, N. Y., Dec. 3-8, Charles F. Roth, director, Grand Central Palace, New York, N. Y.

National Automobile Show — Grand Central Palace, New York, N. Y., Jan. 5-12. Alfred Reeves, manager, 366 Madison Ave., New York, N. Y.

New Materials and Parts

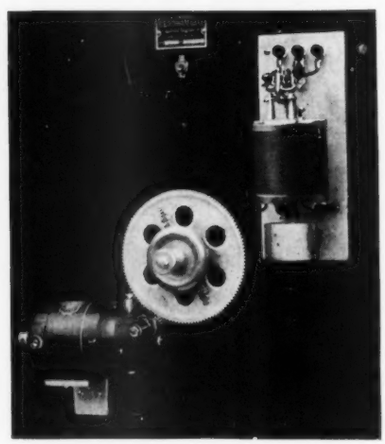
All-Metal Vacuum Tubes



Designed specifically for industrial applications, electronic tubes of all-metal construction are said to be sturdier, more compact, and permit better methods of mounting and cooling. No glass is visible. Metal envelope serving as one element of the tube is welded and sealed to the base by an insulating glass having the same expansion as the metal parts. Leads to the tube elements are insulated by a concentric type of seal. When envelope is used as a rectifier or amplifier anode, cast aluminum radiator shown in the illustration is said to increase the rate of cooling, increasing capacity and reducing the size of the tube. Better cooling is said to result in improved tube performance also. Tube designed to be mounted by studs or clamps with connections made to lugs soldered to flexible leads. General Electric Co., Schenectady, N. Y.

Voltage Adjuster

Designed for use with Diesel, water or steam electric plants. Is connected across the line or through a transformer. Tilting mercury switch controls the operating motor which is geared to a variable resistance in series with the exciter field. Changing voltage causes mercury switch to make contact, starting the operating motor, which adjusts field resistance until voltage changes to correct value. Mercury switch then opens motor circuit. Adjuster provided for line voltage desired, and speed of driving motor is variable. Differential between high and low voltage is also adjustable. Hand-wheel provides manual operation when starting the plant or adjusting the relay. Mounted on a slate panel or in a steel cabinet. All metal parts cadmium plated. R. E. S. Swam & Co., 111 York St., Hanover, Pa.



Valve Position Indicator

Replaces the usual valve handwheel and is adjustable in position to take care of valve seat wear or replacement. When large and small hands are at "SHUT" valve is closed. Large hand rotates one revolution for each turn, the small hand indicating the number of revolutions. Standard indicator is 4¾ in. in diameter; special sizes available. Tefft-Jackson, Inc., 120 Main St., Pawtucket, R. I.

General Purpose Electrode

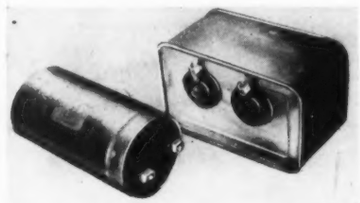
Heavily coated electrode for shielded arc welding on mild steel designed for high-speed, single-pass welding. Is said to have a high burn-off rate with low splatter loss, giving a smooth finished bead. Characteristics claimed for welded metal:

Tensile Strength, lb. per sq.in.	70,000 to 80,000
Yield Point, lb. per sq.in.	55,000 to 60,000
Elongation in 2 in., per cent	20 (approximately)

Resistance to corrosion is said to be greater than that of mild steel. Lincoln Electric Co., Cleveland, Ohio.

Condensers for Capacitor Motors

Both electrolytic and oil-filled condensers for condenser-start motors obtainable in round rubber-insulated or standard cans, and in rectangular cans with or without insulating jackets. Electrolytic units are sealed preventing evaporation or absorption so that moisture content remains stable. Spacer of special composition protects units against surges. All internal metal parts are aluminum. Containers are designed to be leak and seepage proof. Oil-filled units for condenser-transformer motors and power factor correction are available in round and rectangular containers. Designed so



that oil circulation cools the condenser as section expands under load and contracts when at rest. Either type obtainable with any desired terminals. Aerovox Corp., 70 Washington St., Brooklyn, N. Y.

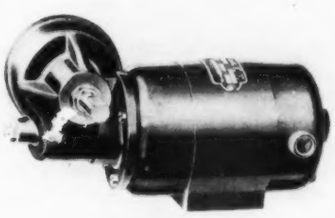
Motor-Mounted Switch

Compact, easily-installed starting switch, designed for use when hand-operated control at the motor is required. Intended for direct mounting on built-in terminal box of standard G-E fractional-horsepower motors. Uses a positive snap-action mechanism, replacing standard terminal-box cover-

plate, and requires no soldered connections or additional wiring. Switch case does not project as far from the frame as the bearing housing. Suitable for use where overload protection is not required and where locked-rotor current need not be broken. The single pole type is rated at 6 amp., 125 volts or 3 amp., 250 volts. General Electric Co., Schenectady, N. Y.

Geared Fractional Motor

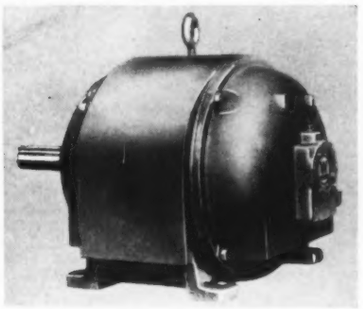
Of the universal type, operating on either direct or alternating current, built-in speed reducer is designed to carry the full power of the motor.



Available only in single-gear reductions, ratios are supplied giving shaft speeds of 1,300, 448 and 191 r.p.m. Grease-type gear housing forms an integral part of the motor frame. Gear units can be positioned on the motor case to project shafts at an angle perpendicular to the motor shaft. Worm thrust carried by a single ball thrust bearing. Forced air ventilating system used. Available with 1/7 hp. rating, weighing 7½ lb. The Dumore Co., Racine, Wis.

Splash-Proof Motor

For use indoors or outdoors where drippings or splashing liquids are encountered. Motor frame and end brackets are solid castings with thick sections. Conduit box is made of cast iron. Baffle plate cast integral with the inner side of the motor bracket prevents splashing liquids from reaching the motor windings. Available with ball or sealed sleeve bearings in both squirrel cage and wound rotor types. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

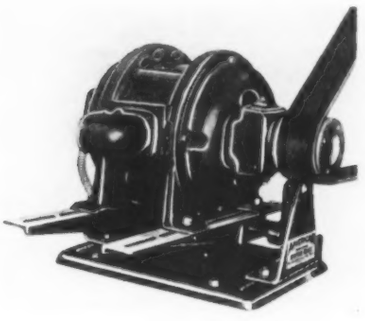


Paint Fluid Hose

Tube lining is a recently developed compound said to have the strength and flexibility of rubber with no tendency to soften or disintegrate in contact with oils and solvents. Couplings are also said to hold better, maintaining a firm grip on the composition. Using a braided and molded construction, hose designated as Type DB is available in inside diameters of ⅝ to ½ in. Electric Hose & Rubber Co., Wilmington, Del.

Industrial Pyrometers

Of the expansion type, temperature measuring device is operated by the difference in expansion of a metallic rod and a fused silica tube around the rod. Alloy is said to withstand repeated cycles of heating to 2,000 deg. F. and cooling without changing characteristics. Instruments supplied in three ranges with four tube lengths from 17 to 45 in. Available in indicating or recording types, with or without electrical control contacts. Fused silica tubes are said to have little expansion and to be unaffected by rapid heating. The R. Y. Ferner Co., Investment Bldg., Washington, D. C.



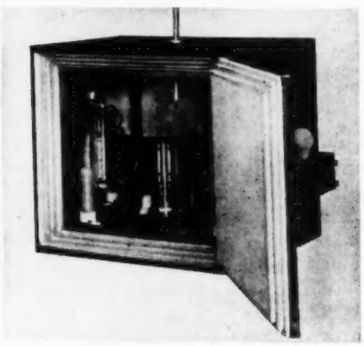
Tension Control Motor Base

For short-center flat belt drives, motor base is designed to produce a belt tension varying in proportion to the load. Types available for floor, wall, ceiling mounting or downward drive applications. The motor is suspended in a cradle free to rotate through a limited range about a pivot axis close to the motor axis. As reaction torques swing motor about the pivot axis, center distance is increased to compensate for belt stretch or driv-

ing tension. Base is built of pressed steel parts. American Pulley Co., Philadelphia, Pa.

Flexible Aluminum Paint

Said to give a smooth, brilliant finish, resistant to salt water, chemical fumes, humid atmospheres, corrosion and rust. For use on both indoor and outdoor applications. Roxalin Flexible Lacquer Company, 800 Magnolia Ave., Elizabeth, N. J.

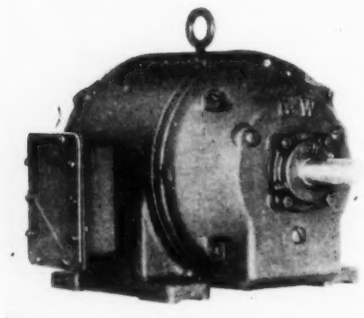


Constant Temperature Cabinet

For obtaining reliable measurements of insulation resistance under conditions of controlled humidity. Said that the cabinet maintains an internal temperature to within 0.1 deg. C. from 25 deg. to 100 deg. C. Cabinet is 18 in. x 18 in. x 18 in., inside measurements. Sound Engineering Corp., 416 N. Leavitt St., Chicago, Ill.

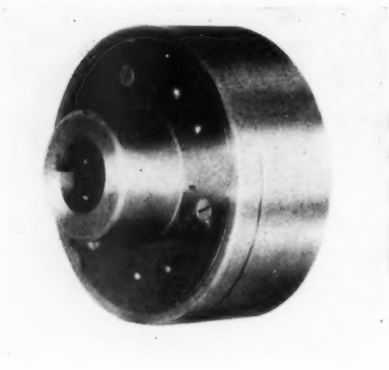
A.C. Splash-Proof Motor

For use in dairies, breweries, bottling and meat packing plants. End flanges are solid with exception of fan-cooled air-circulation baffled opening at the bottom, and are designed with water tight joints for the flanges, ball bearing housings and junction boxes. Windings are treated to withstand moisture, alkali fumes and nonconductive abrasive dust. Built in sizes up to 30 hp., in same frame sizes used for open type motors of corresponding ratings. Rated at 50 deg. C. rise under full load continuous duty. Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.



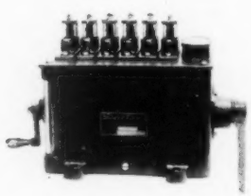
Flexible Coupling

Six solid rubber balls are used as a driving medium between the spider and flange and separated by a ball retainer. It is claimed that these rubber balls give torsional flexibility, freedom from noise and vibration and require no lubricant. By removing the driving balls, the drive can be disconected for testing purposes. Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.



Force Feed Lubricator

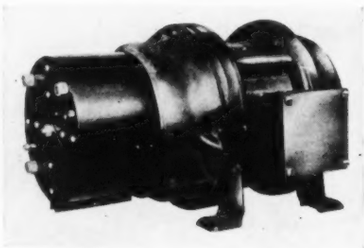
A six feed, eight pint, built-in drip sight feed lubricator, intended for service where delivery is to be checked at the pump. Designed so that should failure occur on the suction side, no oil will pass through the sight feed



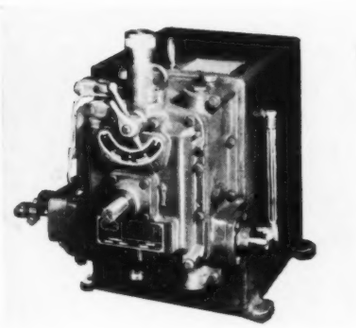
intake nozzle. If trouble should occur on the discharge side, the oil will fill the sight feed glass. No by-passes are provided. Claimed that this pump will purge itself of any air that may be trapped in the pump body. Feed may be set for 1 to 10 drops at each stroke against pressures up to 2,000 lb. Hills-McCanna Co., 2345-59 Nelson St., Chicago, Ill.

Electric Brake

A disk-type brake for controlling small hoists, cranes and winches designed for a continuous braking torque of 50 lb.-ft. and intermittent braking torque of 75 ft.-lb. Obtainable completely mounted on various types of motors, or as a separate unit for floor mounting with other types of motors



already in service. Braking pressure is applied, whenever the motor power supply is interrupted, by an adjustable calibrated helical spring which forces the non-rotating disk against the rotating one splined on the motor. When the voltage is reapplied to the motor, and the braking torque is removed, the spring is compressed and pressure against the disk is released, allowing the shaft to turn freely. General Electric Co., Schenectady, N. Y.



Feed Control Pumps

Hydraulic type of feed, claimed to eliminate screws, clutches and gears, and designed for integral part on machine. A low volume, high pressure, variable-output pump, through automatic compensators for temperature and pressure variation is said to provide a smooth feed. A large volume, low pressure constant-delivery pump, provides high speed approach to and return from the feeding position. The

operating valve in the pump case may be manual, semi-automatic or fully-automatic. One or two pre-set feeds can be obtained in either or both directions. Rapid traverse speed is available in both directions. The Oilgear Co., 1301-1417 West Bruce St., Milwaukee, Wis.

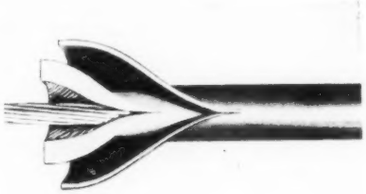
Temperature Recorder

High-speed recorder with response sufficiently rapid to indicate the temperature of moving billets as they leave the heating furnace or fluctuation in

temperature as they pass through the rolling mill. Claimed to be ten times faster than their former industrial recorders and is unaffected by vibration. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

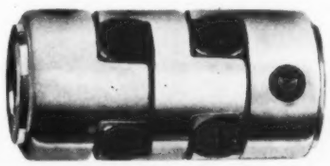
Ignition Cable

Using synthetic rubber insulation, cable is said to resist high temperatures, hot oil and the decomposing effects of corona. Designated as Belden 7799, it is provided with a special orange rubber compound core and a thin synthetic rubber jacket. Belden Manufacturing Co., Chicago, Ill.



Flexible Couplings

Used for oil burners, office devices, coin operated musical instruments and air conditioning units. Has an aluminum center unit with staggered jaws facing in both directions. Two spider cushions are used for quietness and flexibility. Coupling is made for shaft diameters up to and including ½ in. Lovejoy Tool Works, 5007 West Lake St., Chicago, Ill.



Governor-Controlled Motors

Available in series and compensated-series types with an approximate speed range from 500 to 7,500 r.p.m.; also with built-in worm gear speed reducers with ratios up to 60 to 1. Accuracy of speed control is said to closely approach the performance of synchronous motors, the speed being little affected by variations in load within the capacity of the motor. Electric governors are of two forms, one adjustable while the motor is running,

and one which can be adjusted only at standstill. Available in ratings up to ¼ hp. Bodine Electric Co., 2264 West Ohio St., Chicago, Ill.

MANUFACTURERS' PUBLICATIONS

Alloy Iron—Republic Steel Corp., Youngstown, Ohio. Bulletin No. Adv. 132, "Thumbs down on Rust," giving composition of "Toncan" iron with application photographs.

Ball Bearings—The New Departure Mfg. Co., Bristol, Conn. 8 page booklet 8½x11 in. Line drawing applications of "Mine Car" bearings with integral seals, also dimensioned drawings for moutings to accommodate gross loads from 9,000 to 18,000 lb.

Ball Bearing Lock Nuts—Dardelet Threadlock Corp., 120 Broadway, New York, N. Y. Bulletin 12A, describes application of locking ball bearing, without lock washer.

Castings—Michiana Products Corp., Michigan City, Ind. Booklet, 8 pages illustrates nickel-chromium alloy castings classifying various alloys. Pictures of numerous parts.

Chain — Link-Belt Co., 519 N. Holmes Ave., Indianapolis, Ind., 12 page revised booklet with data and installation pictures of ⅜ in. pitch silent chain drives.

Clutches—The Conway Clutch Co., Cincinnati, Ohio, Bulletin 36, 8 pages, includes catalog information and describes design of compression clutches including an asbestos friction type for hoists.

Gears — Philadelphia Gear Works, Erie Ave. and "G" St., Philadelphia, Pa. Catalog 48 pages, 8½x11 in. "Power Saving Products," listing gears of all types, speed and motor reducers and couplings with pages of horse-power capacities of spur gears and rules for gear calculations.

Illumination — Westinghouse Lamp Co., 30 Rockefeller Plaza, New York, N. Y., "Illumination Handbook" 64 pages 4x6½ in. A guide for interior lighting and floodlighting installations with design data and specifications.

Industrial Cable — General Electric Co., Schenectady, N. Y. Publication GEA-1838, 128 pages, 8½x11 in. describing and listing all types of insulated wire and cable for transmission, distribution and control.

Oilless Bearings—Spadone Machine Co., Inc., 122 E. 25th St., New York, N. Y. Describing "Metaline" oilless bushings and their applications with a table of sizes.

Relays — Weston Electrical Instrument Corp., Newark, N. J. Bulletin, 12 pages, "Weston Relays," showing sensitive, toggle, polarized, power and time delay relays.

Steel—Carnegie Steel Co., Pittsburgh, Pa. Booklet, 16 pages, 8½x11 in., "Effects of McQuaid-Ehn Grain Size on the Structure and Properties of SAE 1040 Steel." Discusses characteristics and properties of coarse and fine grain steels. Illustrated with photomicrographs and charts.

Steels — Crucible Steel Co. of America, 405 Lexington Ave., New York, N. Y. Section 3 of general catalog, 79 pages, 8½x11 in. "Corrosion and Heat Resisting Steels," giving

properties and many pictured applications. Section 2-B, 24 pages, 8½x11 in. "Machinery Steel" with applications and physical properties.

Steel—Universal Steel Co., Bridgeville, Pa., and Cyclops Steel Co., Titusville, Pa. Booklet, 31 pages 3½x6½ in. describes a molybdenum-tungsten high speed steel.

Steel—Bethlehem Steel Co., Bethlehem, Pa. Catalog 127, 36 pages, 6x9 in., describes general uses of corrosion-resisting steels with physical property charts and general information.

Steel — United States Steel Corp., P. O. Box 62, Pittsburgh, Pa. Bulletin, 8 pages, announcing three high-tensile steels for light weight construction. Chemical and physical properties given.

Stainless Clad Steel—Ingersoll Steel & Disc Co., 310 South Michigan Ave., Chicago, Ill. Manual, 15 pages, 8½x11 in. of welding and fabricating procedures for clad steels, with drawings of welding technique and application photographs.

Shaftless Motors—The Louis Allis Co., Milwaukee, Wis. Bulletin 516, 8 pages, illustrates installations of frame and shell types. Tables of mounting dimensions are given.

Synthetic Rubber — Thiokol Corp., Yardville, Trenton, N. J. Circular, 12 pages, "What Thiokol is Doing for Industry," with applications of gaskets, hose diaphragms, packing and cable covering.

Tantalum—Fansteel Products Co. Inc., North Chicago, Ill. Illustrated booklet, 3½x8½ in., for use in overcoming severe chemical corrosion problems. Also application photographs and test charts.

Tubing — Summerill Tubing Co., Bridgeport, Pa. Two bulletins, one being non-technical, describing the process of making cold drawn seamless steel tubing, the other telling about tubing specialties, including a sample of hypodermic needle tubing.

BOOKS AND BULLETINS

1934 Supplement to A.S.T.M. Standards

216 pages, 6x9 in., paper covers. Published by American Society for Testing Materials, 260 South Broad St., Philadelphia, Pa. Price, $1.

Included in this first supplement to the 1933 Book of A.S.T.M. Standards, which contains 49 recently adopted or revised standards, are: welded boiler tubes, resistance-welded and forge-welded steel pipe, mild steel plates and nickel-chromium electrical resistance alloys.

N. E. M. A. Motor and Generator Standards

171 pages, 8x10½ in., stiff paper covers. Published by National Electric Manufacturers Association, 115 East 44th St., New York, N. Y. Price $2.

Representing standardized practice in the United States, this reference work includes practical information on the manufacture, test and performance of alternating and direct current rotating machinery. Classes of standards, various commercial standards, the application and selection of rotating apparatus, standard lettering and dimensioning practice, connections, marking of terminals, and definitions of terms are included.

For various types and sizes of motors separate sections give rating and performance standards, pulley and belt dimensions, shaft extensions, dimension tolerances, nameplate marking and other standard information. A complete index is included.

Bibliography on Vibrations in Electrical Conductors

Published by the Transmission and Distribution Committee of the American Institute of Electrical Engineers, 33 West 39th St., New York, N. Y., 150 pages, 8½x11 in., mimeographed.

Extensive list of nearly 1,000 references to published books and articles dealing with the vibration of cables. Divisions include groups of references on vibrations of small amplitude, vibrations caused by formation of ice, wind pressures, wire rope research, sound and noise, fatigue, and inelastic behavior of springs.

Influence of Notches on Fatigue of Metals

National Bureau of Standards, *Research Paper RP 725*, by D. J. McAdam, Jr., and R. W. Clyne, 46 pages, 5 cents.

Percentage decrease in fatigue limit caused by a notch is shown to increase with the tensile strength. Since the endurance limit with smooth specimens also decreases with tensile strength, the advantage of greater unit tensile strength is offset by increased notch sensitivity. Moderate work hardening of copper and nickel-copper alloys increases the endurance limit in proportion to the increase in strength, but for notched specimens the fatigue limit may be greater for annealed than for work-hardened metals. In heat-treated non-ferrous alloys sharp notches are shown to cause a greater reduction in endurance limit than is gained by heat-treatment in some instances. Internal flaws lower the apparent notch sensitivity and influence the ratio between endurance limit and tensile strength. For metals hardened by heat-treatment or cold work internal flaws lower the endurance ratio. Paper includes a bibliography of 33 references, 13 charts and 3 long tables summarizing a large number of tests.

Accelerated Tests of Nickel and Chromium Plating on Steel

National Bureau of Standards, *Research Paper RP 724*, by P. W. C. Strausser, A. Brenner, and W. Blum, 8 pages, 5 cents.

Plated specimens of nickel and chromium on steel, similar to those used in atmospheric tests, were subjected to salt spray and intermittent immersion. Relative extent of rust at the end of a definite time period compared closely with results of atmospheric tests. Although accelerated tests did not reproduce atmospheric corrosion effects, nor disclose small differences in protective value, both spray and immersion tests are said to be useful for determining the relative quality and porosity of copper, nickel and chromium coatings.

High Speed Belt Drives

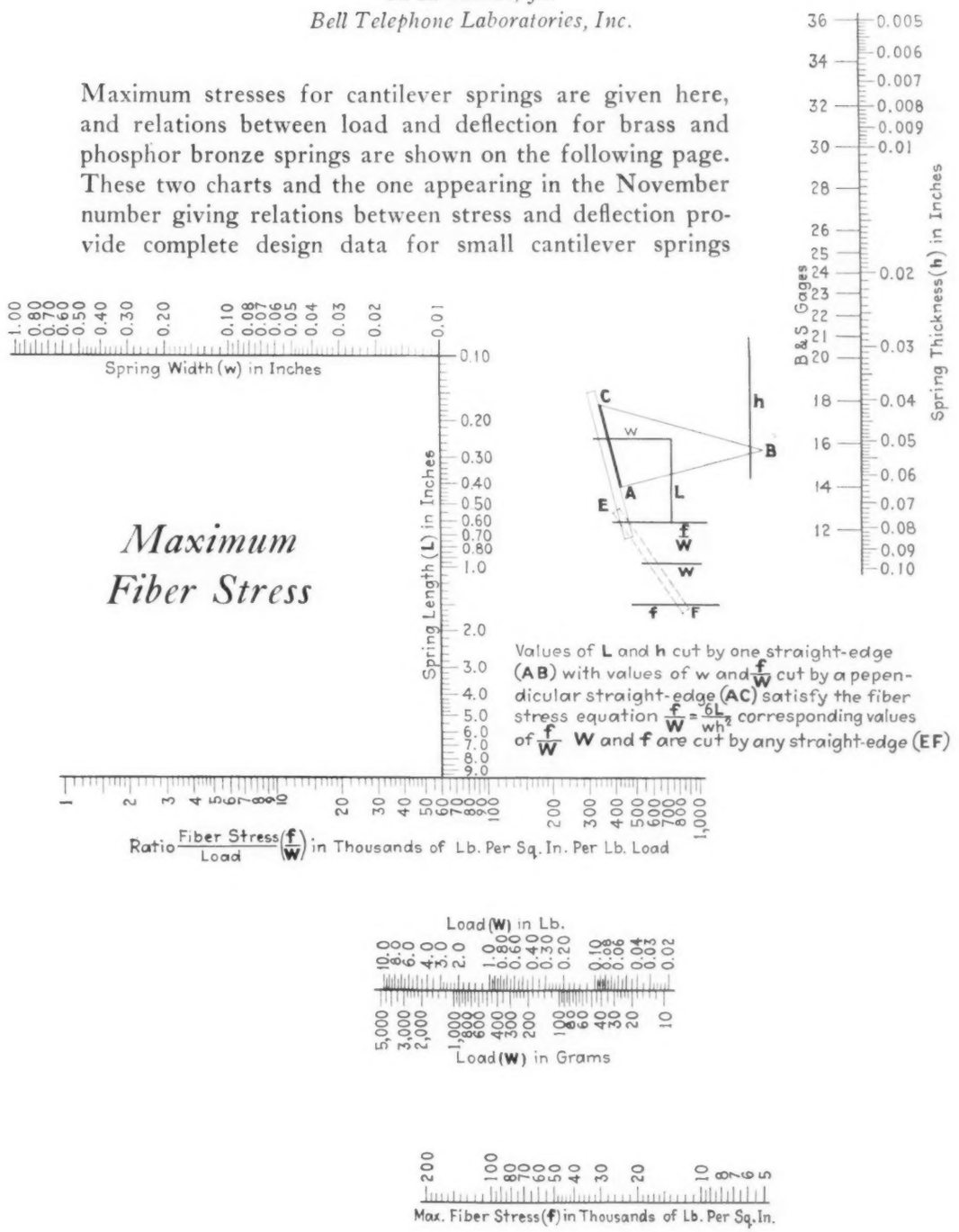
Ohio State University, Engineering Experiment Station, *Bulletin No. 83*, by C. A. Norman, 31 pages, 25 cents.

Relations are developed for the effect of centrifugal force, belt stiffness and change in center distance. Measurements are reported on elasticity, stiffness, contact angle, and belt slip under various load conditions for several types of belt construction.

Cantilever Spring Design

R. L. PEEK, JR.
Bell Telephone Laboratories, Inc.

Maximum stresses for cantilever springs are given here, and relations between load and deflection for brass and phosphor bronze springs are shown on the following page. These two charts and the one appearing in the November number giving relations between stress and deflection provide complete design data for small cantilever springs


Maximum Fiber Stress
Spring Width (w) in Inches
Spring Length (L) in Inches
Ratio Fiber Stress / Load (f/W) in Thousands of Lb. Per Sq. In. Per Lb. Load
B&S Gages
Spring Thickness (h) in Inches
Values of L and h cut by one straight-edge (AB) with values of w and f/W cut by a perpendicular straight-edge (AC) satisfy the fiber stress equation f/W = 6L/wh² corresponding values of f/W W and f are cut by any straight-edge (EF)
Load (W) in Lb.
Load (W) in Grams
Max. Fiber Stress (f) in Thousands of Lb. Per Sq. In.

Cantilever Spring Design

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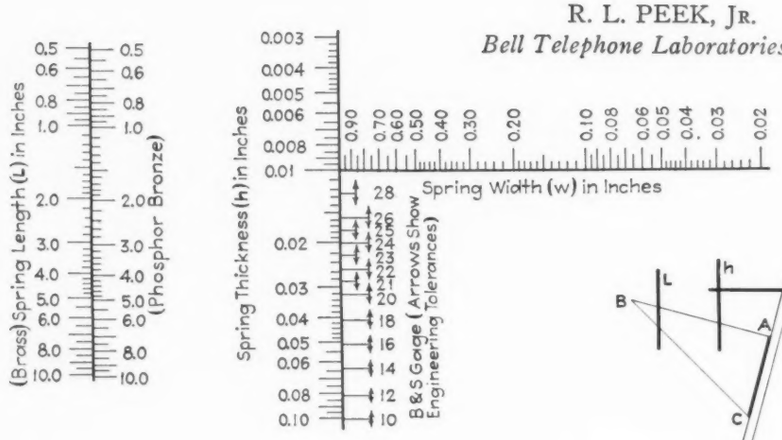
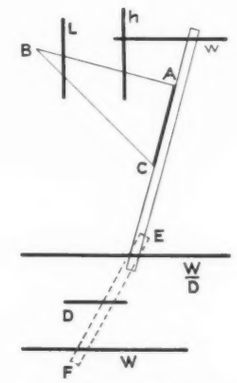
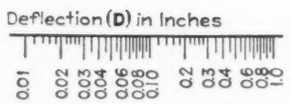

(Brass) Spring Length (L) in Inches
(Phosphor Bronze)
Spring Thickness (h) in Inches
B & S Gage (Arrows Show Engineering Tolerances)
Spring Width (w) in Inches

Relations Between Load and Deflection



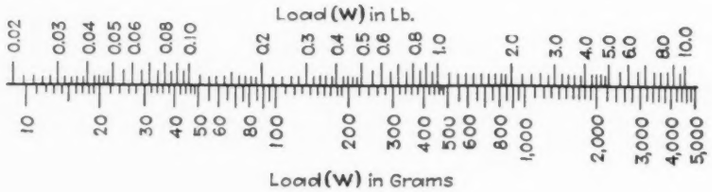
Values of **h** and **L** cut by one straight-edge **(AB)**, with values of w and $\frac{W}{D}$ cut by perpendicular edge **(AC)** satisfy the load deflection equation: $\frac{W}{D} = \frac{wh^3E}{4L^3}$ corresponding values of **W, D** and $\frac{W}{D}$ are cut by straight-edge **(EF)**

Load Deflection Ratio $(\frac{W}{D})$ in Lb. per Sq. In.



Deflection **(D)** in Inches

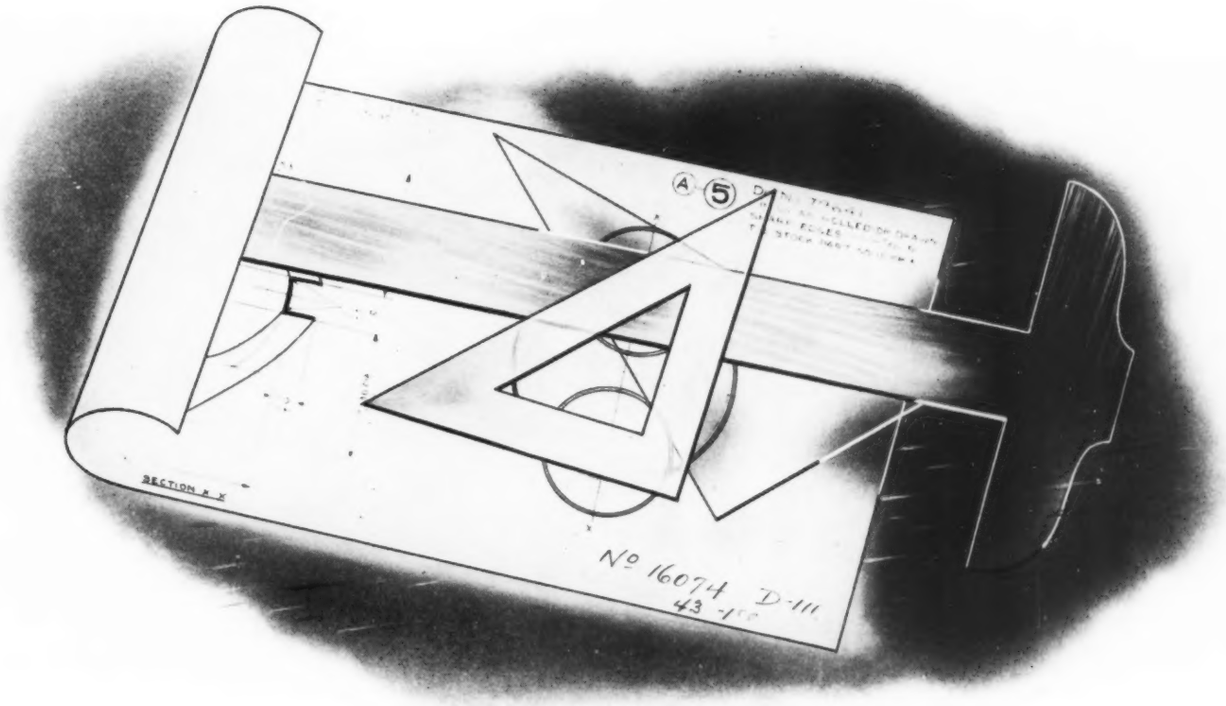
Brass ($E_{min.} = 13 \times 10^6$ p.s.i.)
Phos. bronze ($E_{min.} = 14 \times 10^6$ p.s.i.)



Load **(W)** in Lb.

Load **(W)** in Grams

PRODUCT ENGINEERING © REFERENCE BOOK SHEET



SCOVILL TAKES THE BLUE OUT OF BLUE-PRINTS

THE "Blue-print Blues" is a common ailment of executives entangled in the web of product development and manufacture. It's brought on by problems of product design, selection of equipment, production schedules and plant capacity. It's very contagious—but preventable.

Last year, executives of over 5000 concerns dodged headaches by a most effective method: they turned over their metal part and product problems to Scovill—contract manufacturer of wide experience and versatility.

Scovill men, machines, and methods are well fitted to shoulder details of product development and manufacture where base metals are involved. Let us consider your plans or problems in the light of our facilities. The booklet, "Masters of Metal," gives an idea of our capacities. Write for it to Scovill Manufacturing Co., 35 Mill St., Waterbury, Conn.

SCOVILL

SCOVILL

NRA

SCOVILL MANUFACTURING COMPANY, WATERBURY, CONNECTICUT

Boston Providence New York Philadelphia Atlanta Syracuse Detroit Chicago Cincinnati San Francisco
Los Angeles In Europe: The Hague, Holland Licensees in Canada: A. Schrader's Son, Inc., 334 King Street, E., Toronto, Ont.

Intangibles...

You can accurately measure

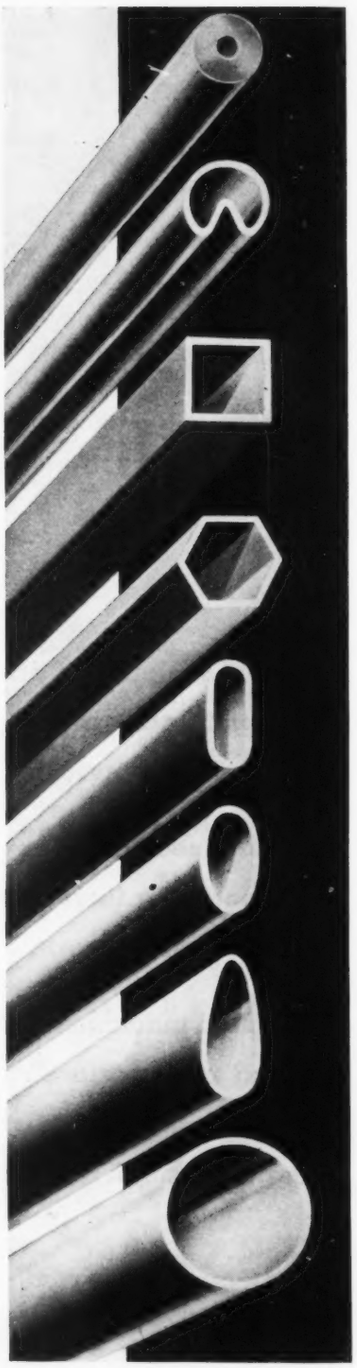
—dimensions

—weight

—hardness

—chemical composition

—physical properties



All these characteristics lend themselves to positive valuation.

There is no way we know to determine the all important Intangibles of mutually satisfactory business relations, except by *actual experience.*

Quality and service are subject to infinite variation. Who can designate exactly where bad becomes fair, or fair merges into good?

There is only one way to evaluate Quality and Service, and that is *by comparison.*

Summerill invites you to make that comparison.

SUMMERILL TUBING COMPANY

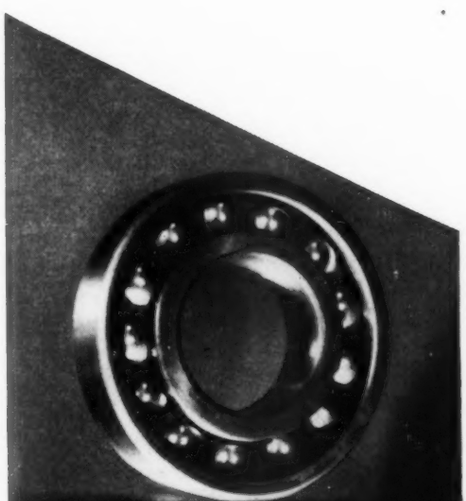
Specialists in Tubing Specialties

BRIDGEPORT, PA.

MACHINES requiring terrific speeds of 50,000 revolutions per minute, and more — as in the air-driven tool shown, can use successfully only the very finest, most efficient anti-friction device—the ball bearing — a New Departure.

It is in such installations that the extremely fine design, materials and workmanship of New Departures are proved most dramatically.

However, they add long life and economy of operation to *any* machine. New Departure engineers are at the service of manufacturers everywhere in planning bearing installations. The New Departure Mfg. Co., Bristol, Connecticut.



NEW DEPARTURE
BALL BEARINGS

Nothing Rolls Like a Ball

★

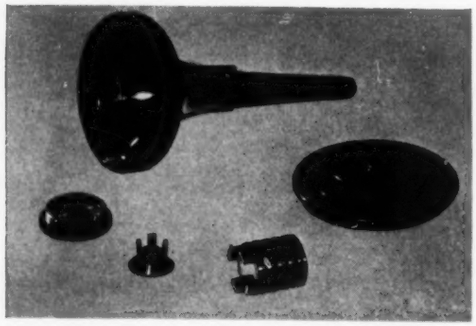
IT SOUNDS LIKE A PRODUCTION MAN'S DREAM—

. . . but it's TRUE!

There actually IS a material that can eliminate as many as six out of thirteen production operations; that is structurally strong, yet light in weight; that provides, in itself, perfect electrical insulation; that has a *permanent* beautiful finish—that is automatically produced in the molding operation; that can be molded into any shape—with all grooves, fastenings, etc. intact—in one single operation; that is absolutely unharmed by water, alcohol, and practically all common chemicals.

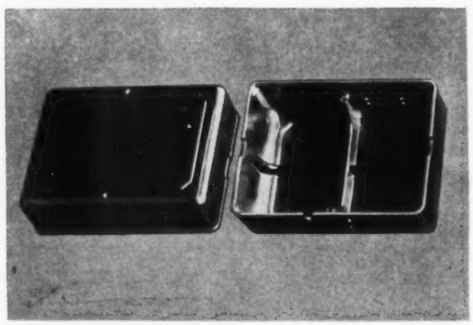
It's Durez . . . the modern molding compound that has revolutionized the manufacture of countless products. Many it has actually made *possible.* For others, it has cut production costs, produced a better, more compact product. . . . and in case after case it has *increased sales.*

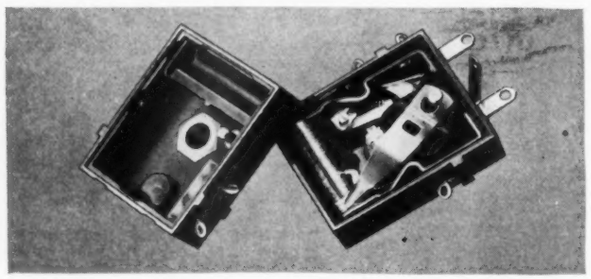
For detailed information on Durez molding compounds write General Plastics, Inc., 711 Walck Road, North Tonawanda, N. Y.



ABOVE—First of its kind, is this molded Durez valve which controls the flow of water in modern toilet. Materials used in past were affected by chemicals found in the water in many localities. But Durez is unaffected by water, alcohol and most common chemicals, and will not corrode or break down even when constantly submerged in them. Such chemical inertness and resistance to moisture make Durez an ideal material for water meter parts, pump and washing-machine parts, film developer trays, etc.

BELOW—In this Bradleyometer one molding operation produces the entire case complete with mountings, grooves, and holes. The high dielectric strength of Durez makes other insulation unnecessary. Because of careful manufacturing methods Durez molding compound is uniform . . . hence the first Bradleyometer will be just like the millionth.





ABOVE—This bell box, when made of metal, required nine production operations . . . blanking, forming, trimming, grinding, sandblasting, phosphate finishing, scratch brushing, japaning and baking. By the use of plastics, the finished product is now turned out in three operations . . . molding, removing fins and buffing. The molded box is light in weight—reducing shipping costs—yet tough enough to take the hardest kind of punishment. Its lustrous black finish is permanent, for it goes all the way through the material; it is not applied.

DUREZ—The Modern Molding Compound

FRONT PAGE NEWS FOR METAL USERS

What's Going On in the Nickel Alloy World—The New Economies—The New Equipment—The New Records for Dependability and Long Machinery Life—Read the Story Month by Month in "Nickel Steel Topics" and "Nickel Cast Iron News"—Sample copies on request

Nickel Cast Iron News
Published in the Interest of Producers and Users of Cast Iron
Nickel Steel Topics
Published in the Interest of Producers and Users of Nickel Alloy Steels
ALLOYED IRON SUPPLEMENTS NEW DESIGN
MIXING KETTLE LIFE EXTENDED BY NEW ALLOY
EFFECTS OF HEAT ON CAST IRONS DESCRIBED
Cost Analysis by Ford Establishes Economy in Use of Alloy Iron Dies
Pressure Vessels for Low Temperatures
Metal Men Gather for Annual Congress
Boulder Dam Cableway Has Capacity of 150 Tons
Minimize Ship Roll

NICKEL CAST IRON NEWS

In November Issue

1. Life of Coke Crusher Rolls Increased 6 Times by Use of "Ni-Hard" Iron.
2. Largest Municipal Power Plant Uses Giant Diesel Engines with Nickel Cast Iron Parts.
3. New Jack for Knee-Action Automobiles Built Largely of Nickel Cast Iron.
4. 50,000 Miles of Trouble-Free Marine Service is Record of Nickel Iron Cylinders and Pistons in Unaflow Type Engines.
5. Alloy Iron in Air-Conditioning Equipment.
6. "Pancake" Engine Developed for Increasing Capacity of Buses, Makes Large Use of Alloy Cast Irons.

NICKEL STEEL TOPICS

In December Issue

1. Welded Nickel Steel Vessels for Low Temperature Oil Refining Operation.
2. "Rainbow" and "Endeavour" Mast Braces Made Stronger and Lighter by Use of Nickel Chromium Steel.
3. New Nickel Molybdenum Steel for Bakelite Molds.
4. 24-Wheeled Vehicle Built in England to Travel Over Darkest Africa Uses Nickel Steels in Vital Parts.
5. Weldless Steel Chains Made by Special Mill with Rolls of Nickel Alloy Steel.
6. Paper Mill Effects Important Savings Using 3½% Nickel Steel Rolls.

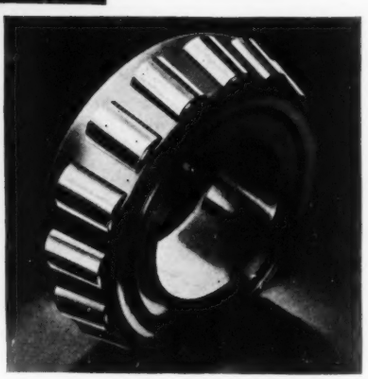
THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.

Miners, refiners and rollers of Nickel. Sole producers of Monel Metal.

NRA CODE

Protected Production

Drum type production milling machine in large automobile factory, showing Fitchburg double and single spindle milling heads. Fitchburg milling heads are completely equipped with Timken Bearings, including the spindles.



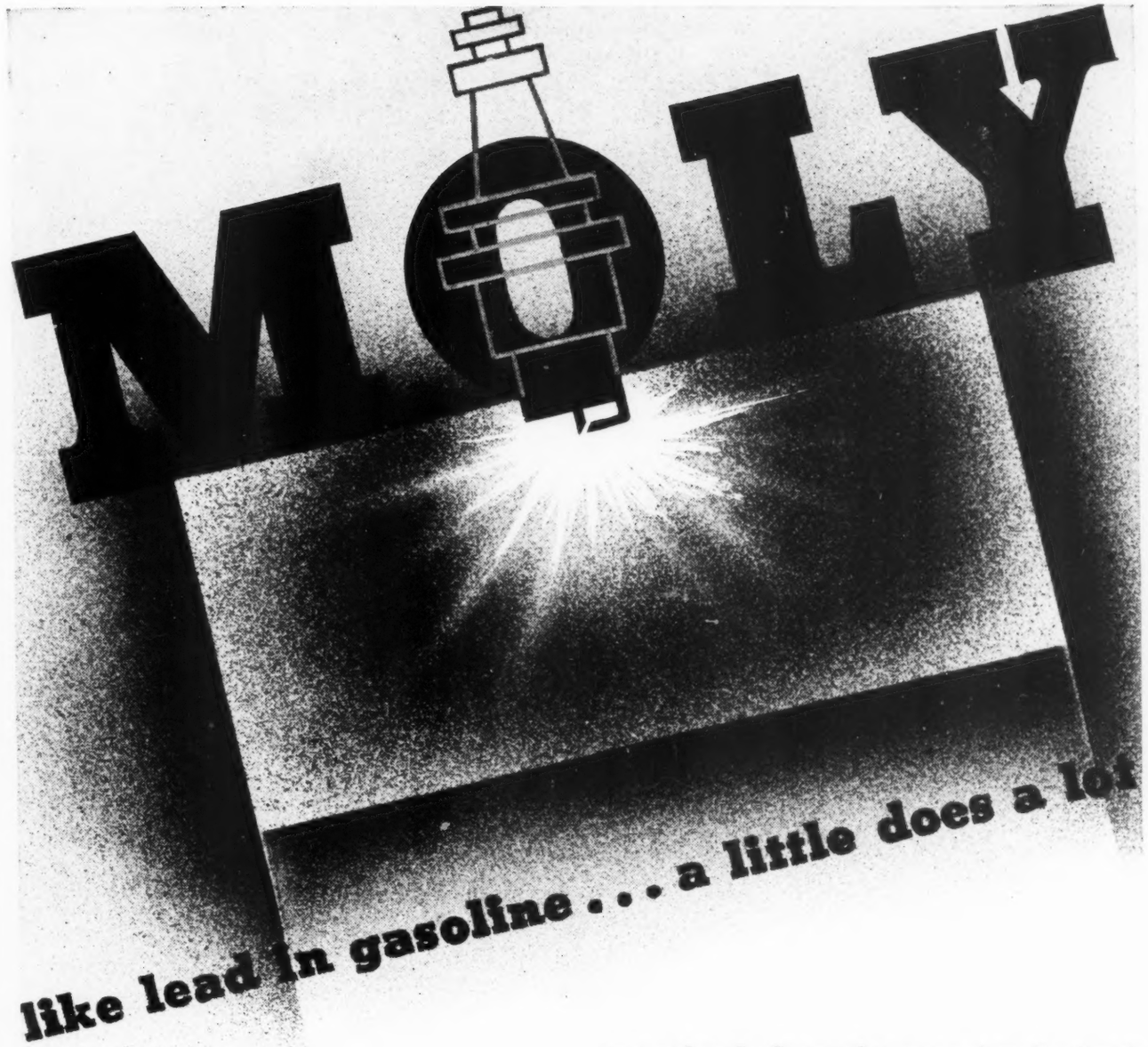
TO protect the quality and output of your product, protect the machines that produce it . . . against friction; wear; radial, thrust and combined loads; and misalignment of moving parts. Timken Tapered Roller Bearings are giving this protection in machines of every type throughout all industry.

You will find them on the spindles of most leading makes of machine tools, where extreme operating accuracy is essential. You will find them on steel mill roll necks where accuracy is combined with load carrying capacity running into millions of pounds. Timken Bearings are important factors in low production costs because they conserve power, save lubricant, reduce material wastage and cut maintenance costs to the bone.

No other type of bearing can give Timken protection because there is no substitute for the exclusive combination of Timken tapered construction, Timken positively aligned rolls and Timken Alloy Steel. Specify Timken Bearings for your new equipment.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**



WHAT is probably the most remarkable of "Moly's" many qualities toward improving iron and steel becomes strikingly apparent in its use in copper-bearing ingot iron. *Less than one-tenth of one per cent* is known to allow the addition of twice as much effective copper in ferrous metals designed to resist atmospheric corrosion and that encountered in mildly acid or oil-refinery liquors.

In fact, service data show copper-Molybdenum ingot iron considerably more resistant to atmospheric corrosion than copper-bearing steels. And one oil refinery claims that in contact with corrosive oils at elevated temperatures this material has outlasted plain carbon steel by *more than three times.*

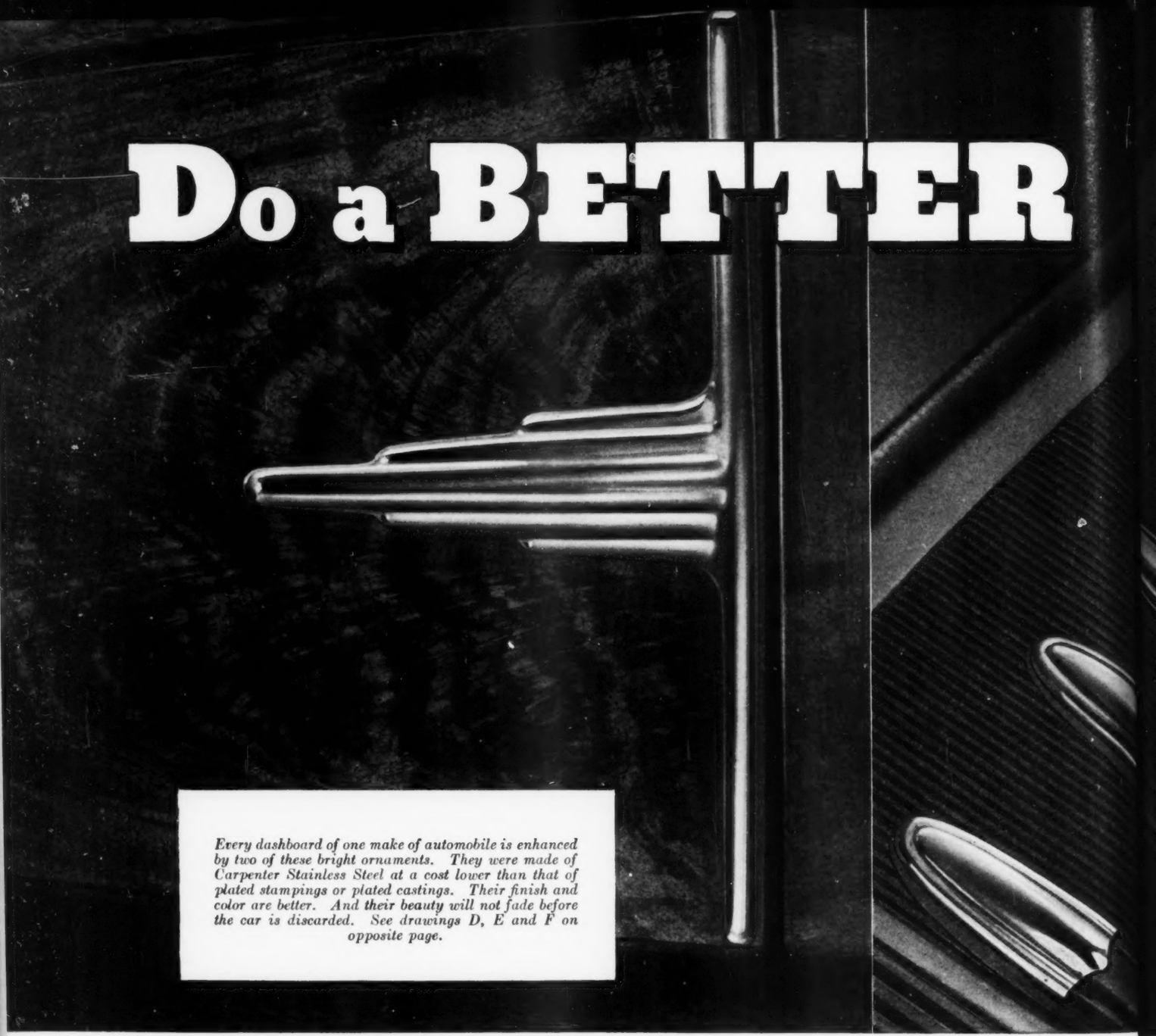
The outstanding development of modern metallurgy is unquestionably the growth in use of Molybdenum irons and steels. In countless uses and applications it has been definitely proved that Molybdenum increases resistance to corrosion, fatigue, shock, creep, abrasion and temper embrittlement in plain or otherwise alloyed irons and steels. Making heat-treated steels easier to machine and weld—without loss of strength—is another of its characteristics. And its ultimate possibilities have not yet been approached.

"*The Moly Matrix*" is our new house organ, planned to help executives and engineers keep informed of Molybdenum's progress. A simple request puts you on our mailing list. A further request brings you either or both of these new books: "*Molybdenum in* 1934" and "*Molybdenum in Cast Iron*—1934 *Supplement.*" And our metallurgists and experimental laboratory in Detroit offer ready assistance toward solving any alloy problems you may have. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

In Canada—Railway & Power Engineering Corporation, Ltd., Montreal

CLIMAX Mo-lyb-den-um

Do a BETTER



Every dashboard of one make of automobile is enhanced by two of these bright ornaments. They were made of Carpenter Stainless Steel at a cost lower than that of plated stampings or plated castings. Their finish and color are better. And their beauty will not fade before the car is discarded. See drawings D, E and F on opposite page.

THESE simple ideas can be used to improve the appearance and salability of hundreds of different products—maybe yours. Both these pieces cost less than plated substitutes that might fail after a couple of years of hard use.

Both of them are far better, too, because they're Carpenter Stainless Steel clear through. You could polish them hundreds of times and you'd always get the same beautifully polished surface.

Cost is low on them because they were designed for Stainless Steel right from the start—keeping in mind the easy-working qualities of Carpenter Stainless Steel Strip and the high quality finishes in which Carpenter now offers it.

If you want to get the advantages of Stainless Steel for your own products and parts, design them from the start for Stainless. Don't try to adapt old designs and patterns to it if you're seriously after lower costs.

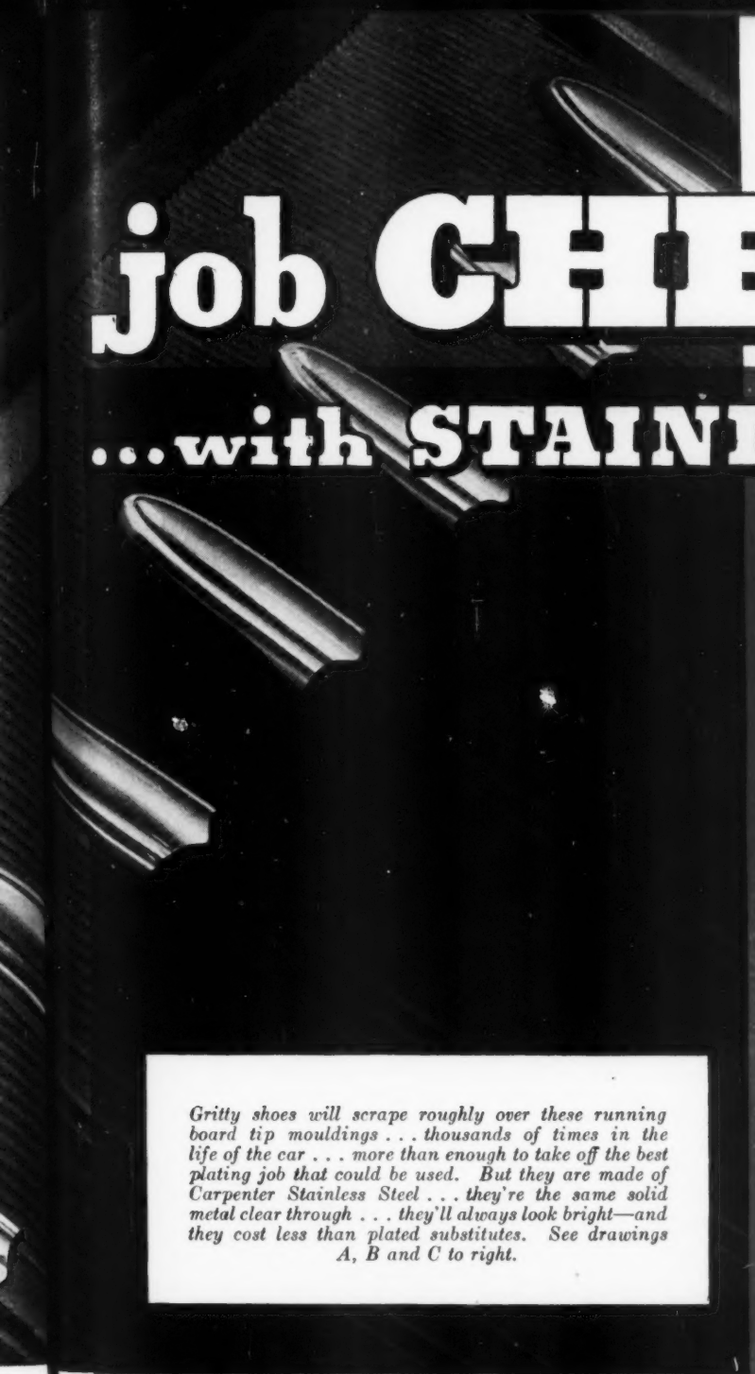
We offer you help in your work with Stainless Steel—a handy, pocket-size slide chart that gives you at a glance a summary of technical data on all stainless steels. You'll find it very useful. Send the coupon below and get one for your desk—free, of course.

THE CARPENTER STEEL COMPANY · READING, PA.

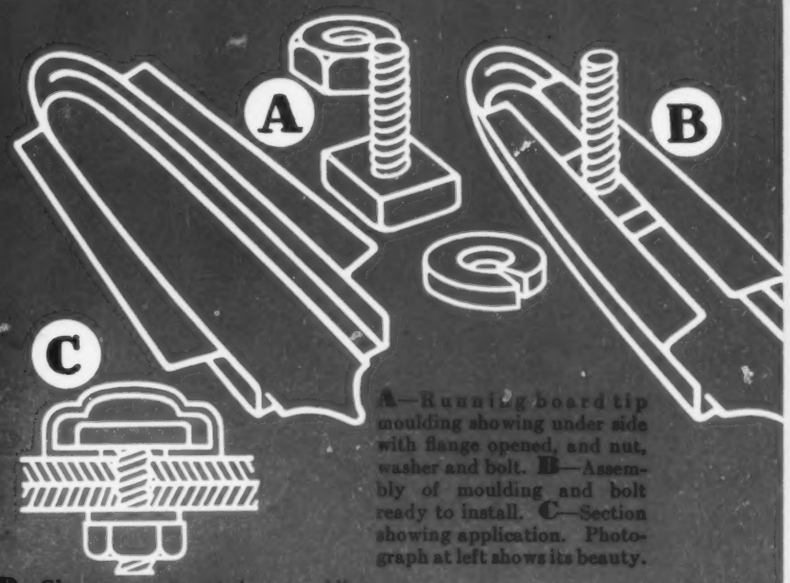
Licensee of American Stainless Steel Company, and of Chemical Foundation, Inc.

Carpenter STAINLESS

job CHEAPER ...with STAINLESS STEEL

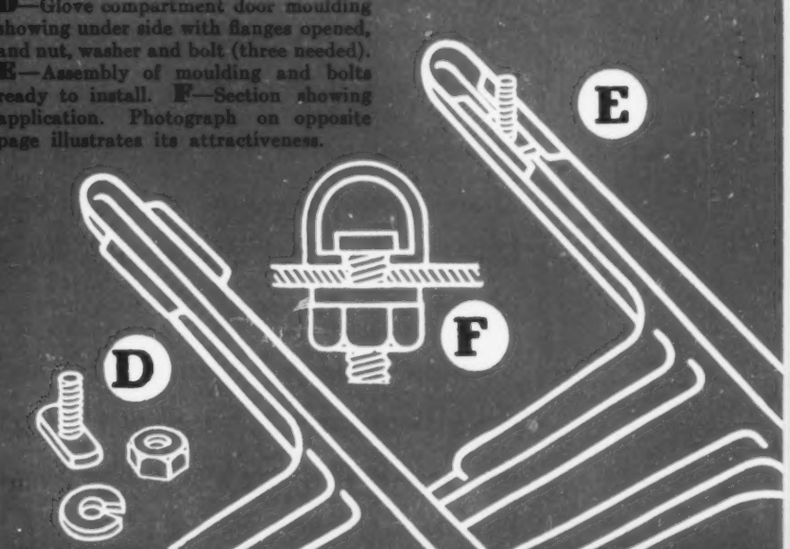


Gritty shoes will scrape roughly over these running board tip mouldings . . . thousands of times in the life of the car . . . more than enough to take off the best plating job that could be used. But they are made of Carpenter Stainless Steel . . . they're the same solid metal clear through . . . they'll always look bright—and they cost less than plated substitutes. See drawings A, B and C to right.



A—Running board tip moulding showing under side with flange opened, and nut, washer and bolt. **B**—Assembly of moulding and bolt ready to install. **C**—Section showing application. Photograph at left shows its beauty.

D—Glove compartment door moulding showing under side with flanges opened, and nut, washer and bolt (three needed). **E**—Assembly of moulding and bolts ready to install. **F**—Section showing application. Photograph on opposite page illustrates its attractiveness.

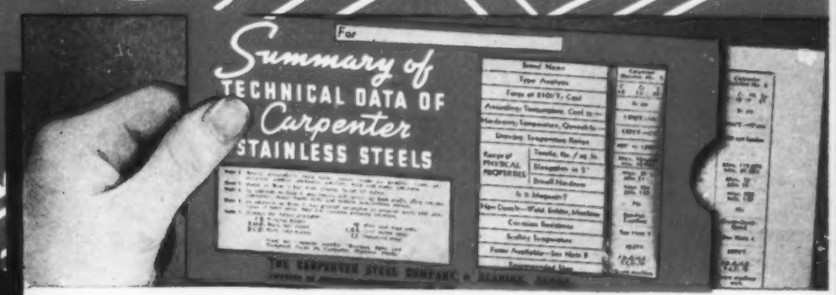


(See A, B, C)

With this simple device for fastening running board tip mouldings—flanges under a flat-headed bolt—a minimum amount of material is used and costs are kept down. They are easy to put on, too. What a lot of effective trim for just a few pennies.

(See D, E, F)

The installation of this trim is very simple. Its design utilizes the minimum amount of Stainless Steel per piece, to get the greatest possible decorative value. The price is kept low because it was designed from the beginning for Stainless Steel.



S STEELS

SEND THIS COUPON *Now*

The Carpenter Steel Co., 117 West Bern St., Reading, Pa.

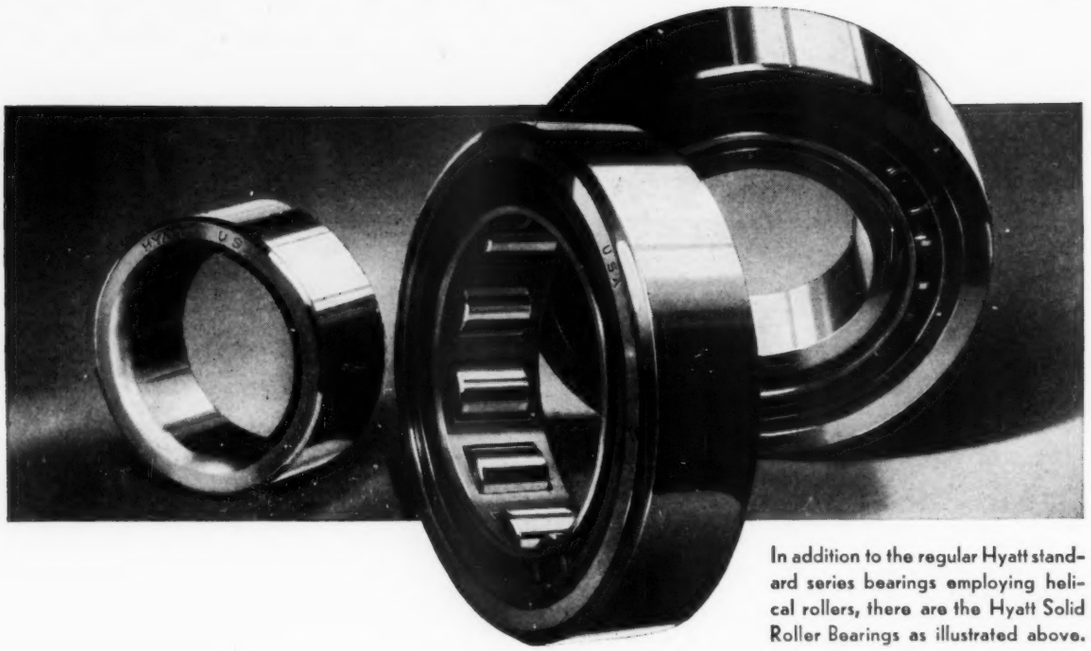
Please send me your free pocket-size slide chart on stainless steel, immediately. Thank you.

Name..... Title.....

Firm Name.....

Street and Number.....

BUILDING BETTER



In addition to the regular Hyatt standard series bearings employing helical rollers, there are the Hyatt Solid Roller Bearings as illustrated above.

With Better Built Bearings

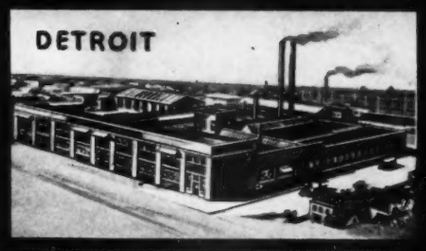
The application of anti-friction bearings is so universal today that scarcely a wheel or shaft turns without them.

But universal as they may be, good judgment must be exercised in the choice of anti-friction bearings. For not all bearings, however similar in appearance, have built into them that quality, long life and carefree performance which characterizes Hyatt Roller Bearings.

Thus, far-seeing manufacturers in building a better product, employ these better bearings. On the correct design, quality manufacture and sound application engineering of Hyatt Roller Bearings, they know they can rely. Hyatt Roller Bearing Company, Newark, Detroit, Chicago, Pittsburgh, Oakland.

HYATT
ROLLER BEARINGS
PRODUCT OF GENERAL MOTORS

THE NATIONWIDE PARKER SERVICE



Illustrating only a few of the 24 Parker Jobbing Service Plants

For the thousands of manufacturers whose rust-proofing requirements do not justify installing Parkerizing equipment of their own, a network of jobbing service plants has been established.

Parkerizing Service extends into every industrial area and is only a few hours distant from any producer who desires a rust-proof finish for his products, whether his requirements are great or small.

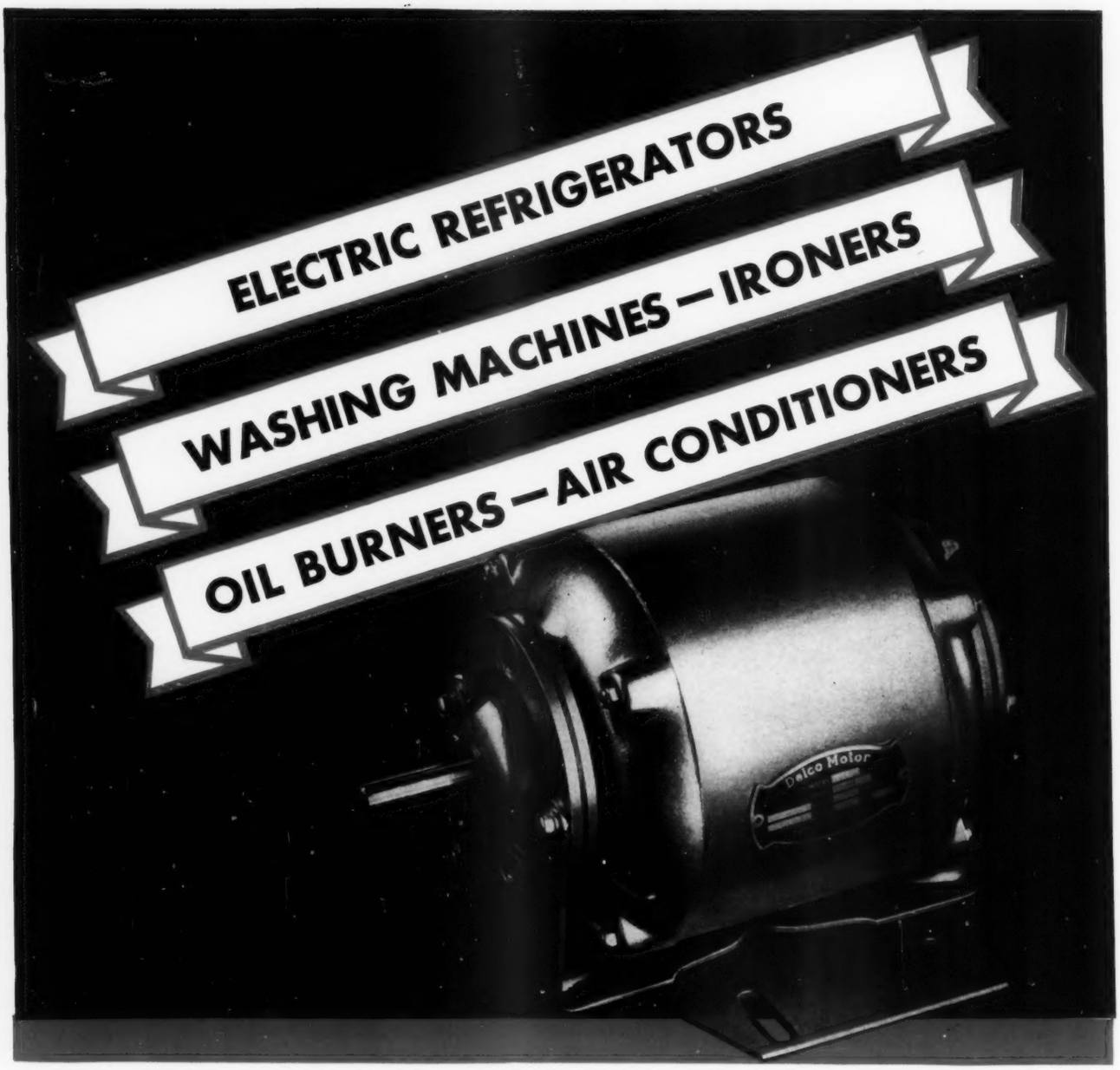
Write or telephone your nearest plant

BALTIMORE, MD., Federal Tin Company, Inc., Parkerizing Dept., Charles and Barre Sts.
BOSTON, MASS., Rust-Proofing & Metal Finishing Corp., Commercial Ave. and Binney St., Cambridge A.
BUFFALO, N. Y., Parker Rust-Proof Co. of Buffalo, Inc., 1095 Niagara St.
CANTON, OHIO, G. C. Reiter
CHICAGO, ILL., Western Rust-Proof Co., 2139 Walnut St.
CINCINNATI, OHIO, The Stolle Corporation, 227-241 W. McMicken
CLEVELAND, OHIO, Parker Rust-Proof Co. of Cleveland, 2617 E. 76th St.
DAYTON, OHIO, Dayton Rust-Proofing Co., 736 N. Main St.
DETROIT, MICH., Parker-Wolverine Co., 2177 East Milwaukee Ave.
EVANSVILLE, IND., Evansville Plating Works
INDIANAPOLIS, IND., The Concealed Door Check Co., P. O. Box 1655
KANSAS CITY, MO., Bar-Rusto Plating Corp., 1808 Locust St.
LOS ANGELES, CALIF., L A Parkerizing Co., 8141 So. Alemeda St.
LOUISVILLE, KY., Republic Welding Co., Inc., 305 College St.
MILWAUKEE, WIS., Hermanson-Nortman Co., 403 So. 7th St.
NEW YORK, N. Y., Pyrene Manufacturing Co., 560 Belmont Ave., Newark, N. J.
PHILADELPHIA, PA., Philadelphia Rust-Proof Co., 3229 Frankford Ave.
PITTSBURGH, PA., Pittsburgh Electro Galvanizing Co., 5th St. and Penna. R. R., Sharpsburg.
ROCKFORD, ILL., Barber-Colman Company
ST. LOUIS, MO., Mid-West Rust-Proof Co., 3665-7 Market St.
SAN FRANCISCO, CALIF., Best & Company, 2006 Clement Ave., Alameda
TORONTO, ONT., Fairgrieve & Son, 50 Dovercourt Road
TORRINGTON, CONN., Turner & Seymour Company, Parkerizing Department
WAYNESBORO, PA., Landis Engineering & Mfg. Co., Inc.

PARKER RUST-PROOF COMPANY, 2179 East Milwaukee Ave., DETROIT

PARKER
RUST-PROOFING
processes
BONDERIZING
PARKERIZING

Parker Processes are the result of 18 years of continuous research, looking to improved technic of rust prevention and better finishes for iron and steel products. Literature describing these processes will be sent on request to manufacturers and technical men.



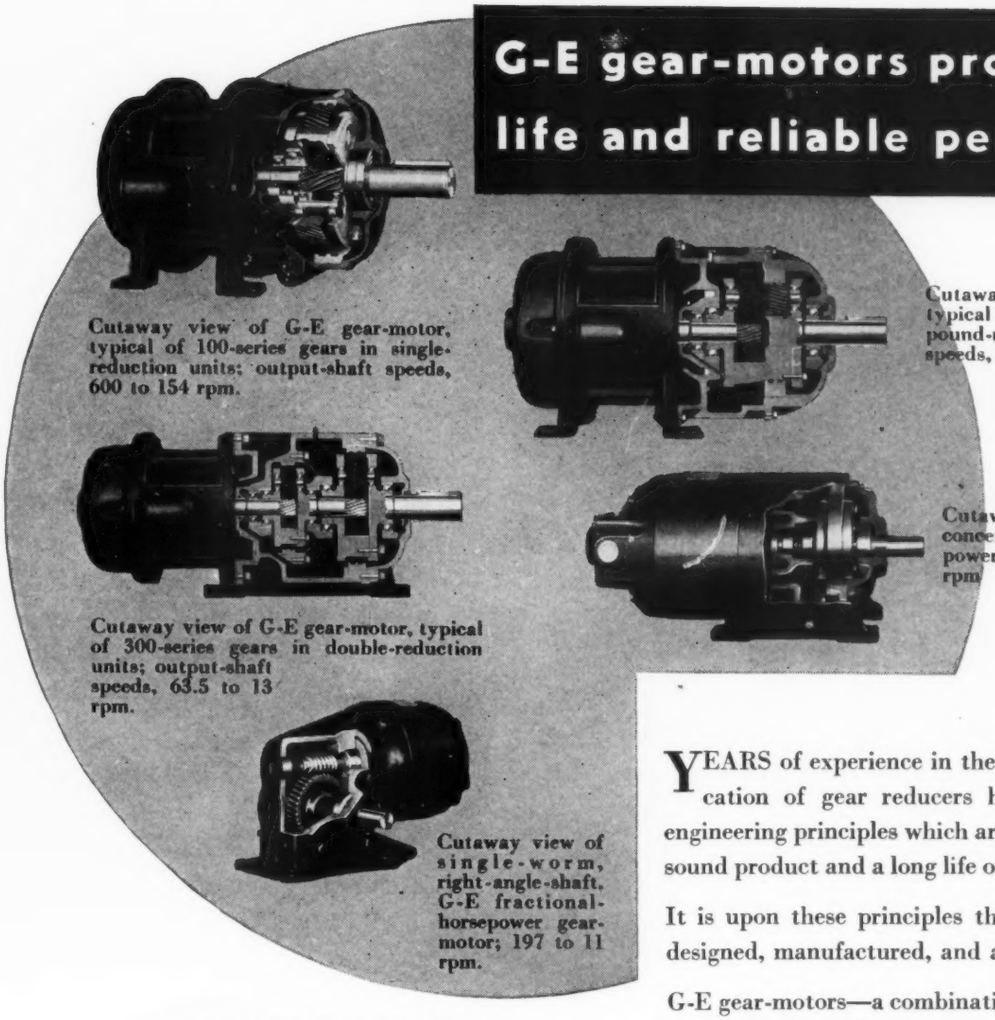
DELCO MOTORS Help Sell Your Product

Because of their widespread reputation for *quietness* and *dependability*, Delco motors are helping to sell a constantly increasing number of household appliances. The value of Delco's *Sealed Lubrication, Vulcanized Rubber Cradle Mounting, and No End-Play Feature* has already been demonstrated in the sale of washing machines, ironers, refrigerators and oil burners. Delco motors are now winning a similar reputation in the newest appliance field —air conditioning. If you want to reduce noise, wear, vibration and operating cost—if you want to insure your owners of *dependable* service—turn to Delco motors. Delco's well-known features and Delco's high manufacturing standards and precision workmanship result in motors that not only sell themselves but also help sell your product.

DELCO PRODUCTS CORPORATION, Dayton, Ohio

SOUND in every detail of design and manufacture

G-E gear-motors provide long life and reliable performance



Cutaway view of G-E gear-motor, typical of 100-series gears in single-reduction units; output-shaft speeds, 600 to 154 rpm.

Cutaway view of G-E gear-motor, typical of 200-series gears in compound-reduction units; output-shaft speeds, 145 to 71 rpm.

Cutaway view of single-planetary, concentric-shaft, fractional-horsepower G-E gear-motor; 500 to 98 rpm

Cutaway view of G-E gear-motor, typical of 300-series gears in double-reduction units; output-shaft speeds, 63.5 to 13 rpm.

Cutaway view of single-worm, right-angle-shaft, G-E fractional-horsepower gear-motor; 197 to 11 rpm.

STANDARD RATINGS

600 to 11 Rpm.

Polyphase, 1/6 to 75 hp.

Single-phase, 1/6 to 5 hp.

Direct-current, 1/6 to 7 1/2 hp.

Other speeds and horsepower ratings can be furnished on request. Mechanical modifications, such as flange mounting, vertical motors, etc., are available.

Speed adjustment can be obtained by selecting a motor with the requisite electrical characteristics.

YEARS of experience in the manufacture and application of gear reducers have established certain engineering principles which are the best assurance of a sound product and a long life of successful performance.

It is upon these principles that G-E gear-motors are designed, manufactured, and applied.

G-E gear-motors—a combination of motor with helical-planetary-type reduction gears—are available in a wide range of sizes and in a number of electrical and mechanical modifications to meet properly your requirements for low-speed drives.

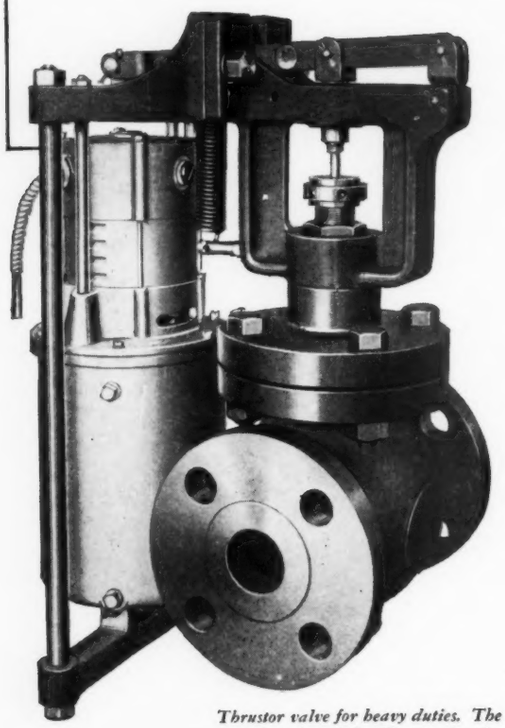
G-E gear-motors provide full-horsepower output at the low-speed shaft. Their inherent characteristics—compactness, efficiency, ease of mounting, simplicity—make them the preferred electric drive wherever low speed is desired.

020-66

GENERAL ELECTRIC

Control of Fluids at your fingertips

with G-E Electrically Operated Valves

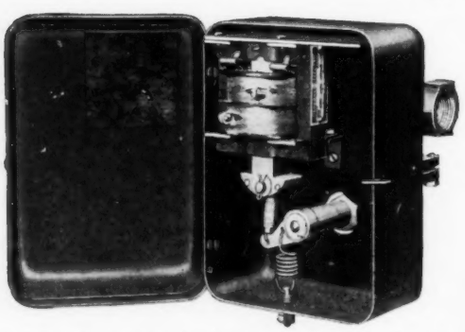


Thrustor valve for heavy duties. The smooth action of the Thrustor is a foe to water hammer; there are few wearing parts.

A G-E electrically operated valve will give you *central, push-button control* of the fluids used in your factory processes, thereby saving workmen's time for other duties. Or, by the use of one of the many G-E valve accessories such as float switches, time switches, limit switches, or thermostats, you can even make the process control itself.

General Electric has the *right* valve for your application, actuated either by the G-E Thrustor or by a dependable solenoid. These are available for a wide range of temperatures, pressures, pipe sizes, or fluids. The G-E nameplate on electrically operated valves assures you of reliability, convenience, and low maintenance.

G-E electrically operated valves are available for all standard voltages and frequencies. Ask our nearest sales office for further information — or write to General Electric, Dept.6B-201, Schenectady, N. Y.



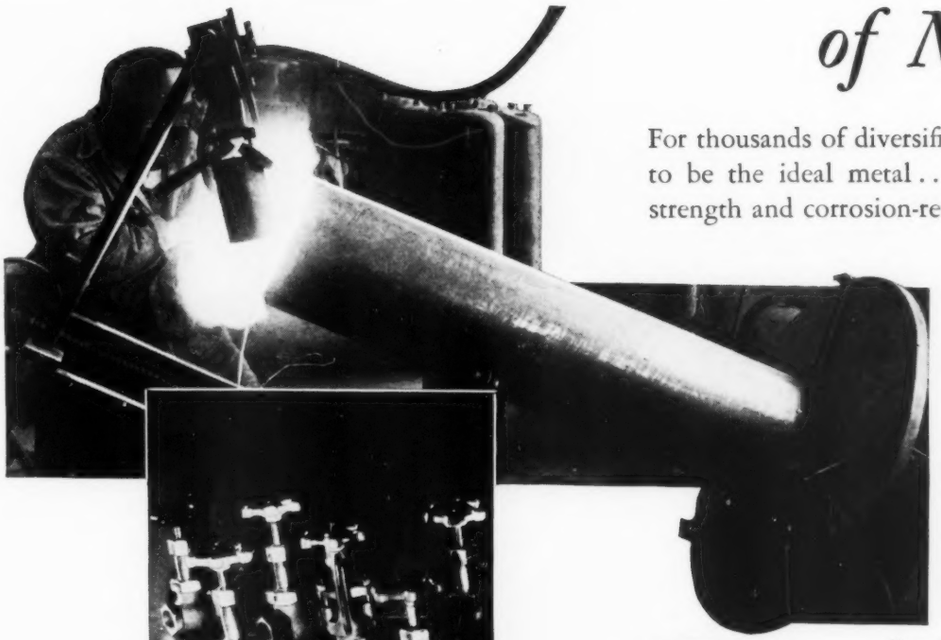
Solenoid-operated valve for pressures up to 250 lb. and temperatures to 700 deg. F.

Right: The new, small, solenoid valve for pressures up to 150 lb., using only 7½ watts at 110 volts, 60 cycles.

080-24

GENERAL ELECTRIC

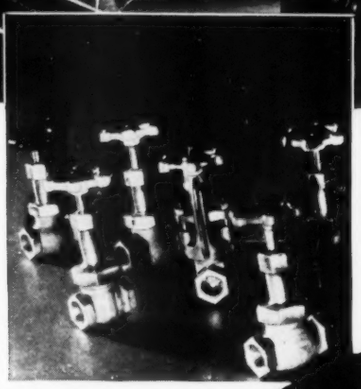
EVERDUR...*Modern Metal of Many Uses*



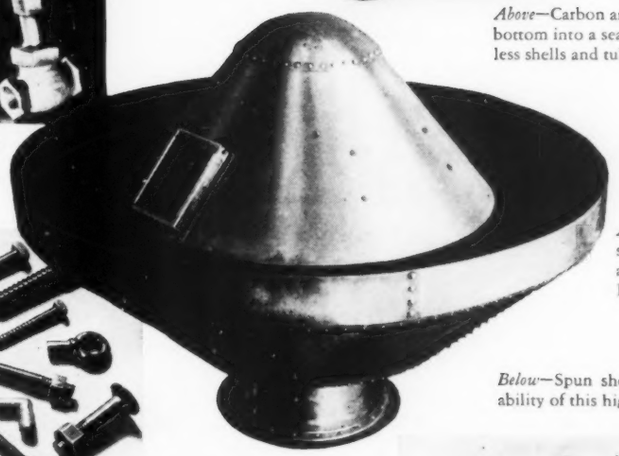
For thousands of diversified uses, Everdur has proved to be the ideal metal . . . because it combines high strength and corrosion-resistance with ductility, weldability, workability and moderate price.

"Everdur" is a registered trade-mark identifying products of The American Brass Company made from alloys of copper, silicon and other elements. Additional information upon request.

Above—Carbon arc welding an Everdur storage tank bottom into a seamless drawn Everdur shell. (Seamless shells and tubes available up to 26" I.D.)



Above—Cast Everdur valves for severe service. Everdur ingots are used for a wide variety of dense close-grained castings—made with the regular equipment of brass and bronze foundries.



At left—Excellent resistance to dilute sulphuric acid, plus high strength and good fabricating qualities, makes Everdur ideal for smoke washers.

Below—Spun sheet Everdur. No end to the adaptability of this high-strength copper-alloy!

Above—Here we have forgings, die-pressings, machined parts, rolled parts and flexible metal tubing. Name the part you need. Then investigate the possibilities of Everdur!

At right—Riveted Everdur digester for process work—8' in diameter. Everdur vessels of all types and sizes are put to endless uses.

ANACONDA
from mine to consumer

THE
AMERICAN BRASS
COMPANY
General Offices: Waterbury, Conn.

ANACONDA COPPER & BRASS

RUBBER Sails The Seven Seas

THERE *is* a sea monster. Since the early days of steamships it has attacked and destroyed propeller shafts and bearings. Its name is *abrasion.* Propeller shafts, of course, work under water, which always contains some sand and grit. These hard particles flow in with the water, are ground between bearing and shaft, and destroy the toughest metal or wood.

An engineer came to Goodrich with an idea for the use of rubber. Bearings were made of soft rubber with longitudinal grooves. When any foreign matter enters this bearing, the rubber depresses and lets it roll harmlessly into one of the grooves, where it is washed out and away.

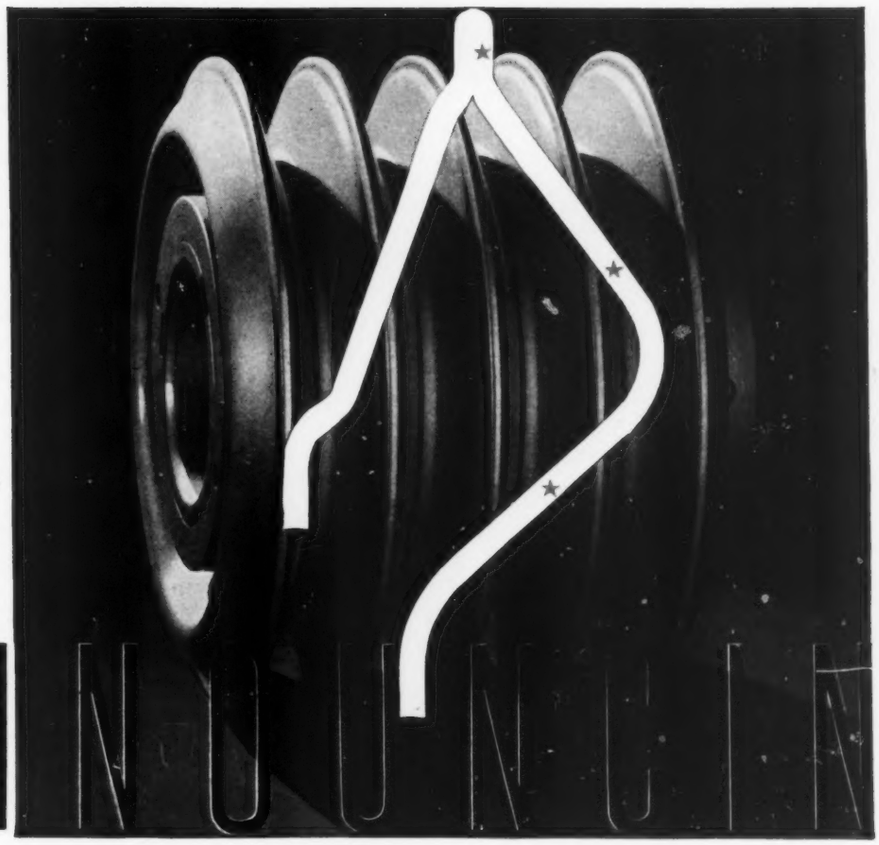
This is the Goodrich Cutless Rubber Bearing, which now sails the seven seas, and lasts (and makes propeller shafts last) five to ten times as long as the former bearings of wood or metal. Here is only one of the countless new uses for rubber, made possible by the new properties Goodrich engineers have given this adaptable material.

If your product or process needs silence, remember that rubber absorbs vibration and noise. If corrosion troubles you, rubber can be made to resist acids, oils, heat. If wear is a factor, rubber can stand abrasion, endless flexing, terrific pressure. If new forms or colors or textures would help your product's sales, rubber can supply them.

New deals and new competition call for new improvements in products and their making. Modern rubber is a *new material,* with infinite new possibilities. Let Goodrich show you what they are. The B. F. Goodrich Co., Mechanical Rubber Goods Division, Akron, Ohio.

Goodrich

ALL *products problems* IN RUBBER

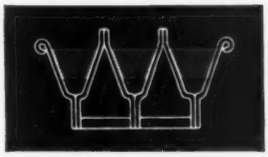


ANNOUNCING!

The new DURO-BRACE TEXSTEEL SHEAVES

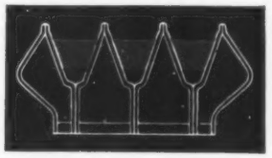
The Allis-Chalmers Manufacturing Company, originators of multiple V belt drives, now offers a new development in sheaves which will withstand the severest duty. • Bending of the outside plate is practically impossible with the new Duro-Brace Sheaves, for in the new design this vulnerable area is braced by a reinforcing convex steel plate, which increases its strength to so great a degree as to eliminate distortion, even under extreme overloads; thus giving a true running drive always. • Duro-Brace Texsteel Drives are 98.9% efficient . . . Require no belt dressing or lubrication . . . Are unaffected by moisture or dust . . . Are Vibrationless, Slipless, Silent, Light and Clean. • Mail us a card asking for Bulletin No. 2188 which sets forth the advantages which Duro-Brace Texsteel Drives offer you in all matters of power transmission, whether they are simple or complex.

Former Design: cross-section showing unsupported outside plate.



★ ★ ★

New Duro-Brace Design: cross-section showing outside plate braced by a convex reinforcing steel plate.



TEXROPE DRIVES

ORIGINATED BY

ALLIS-CHALMERS MANUFACTURING

ALLIS-CHALMERS

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My FIRST
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This Year

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Dear Blue Knight:

Send me your new "HOW GOOD ARE YOU AT TWISTING AND BENDING" booklet without charge or obligation. I understand that sample strips demonstrating your finishes are included and that this new booklet holds something of interest for every lacquer-user. Mail it to me—I'll be looking for it.

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SHAKEPROOF

STRUT ACTION
Holds 'em!

Send today for your free copy of this complete Shakeproof Catalog. Explains thoroughly the many advantages that Shakeproof offers—also shows new patented Shakeproof products.

● It's a far cry from football to Lock Washers, but the "All-American" guard employs the same principle in blocking his opponent as Shakeproof Lock Washers do in holding a nut or screw absolutely tight. It's the strut action of each twisted tooth as it bites into both nut and work surfaces that sets up a powerful leverage against any movement of the nut. This positive locking principle is an exclusive Shakeproof feature and is certain to provide perfect protection for your product against the damaging action of vibration. Write today for free testing samples and see for yourself why Shakeproof should be applied under every nut and screw.

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Distributors of Shakeproof Products
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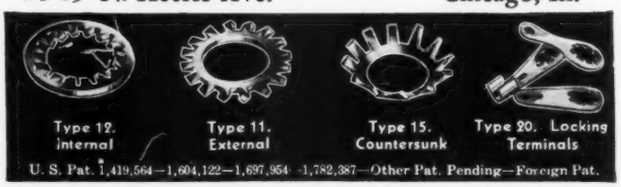

U. S. Pat. 1,419,564—1,604,122—1,697,954—1,782,387—Other Pat. Pending—Foreign Pat.

NEW UNBRAKO NEW

KNURLED
SOCKET HEAD CAP SCREW

Every mechanic, when driving screws, will invariably persevere with his fingers until he has to give up—but not before.

With the Knurled "Unbrako" he can drive much further and faster because his fingers actually become geared to the Knurled head and, therefore, can't slip, regardless of how greasy the head is.

Smooth-head screws, on the other hand, are hard to get hold of and, therefore, much slower to drive.

Then again—the Knurled "Unbrako" can be easily and quickly pinched home and backed off with a pair of pliers. With smooth-heads this would, at best, be very hard to do.

Don't overlook this advantage because you must know of many a tight place where it would be mighty handy to use a pair of pliers if at all practicable.

The Knurled "Unbrako" is of exactly the same high quality as the smooth-head "Unbrako."

U. S. and Foreign Patents Pending

THE KNURLED "UNBRAKO"

Fingers become geared to the Knurled head so they can't slip, which makes the Knurled "Unbrako" a real time and labor saver.

OLD SMOOTH-HEAD

Fingers slip and slide. Hard and slow to drive.

Order by Name—

Specify the Knurled "Unbrako"

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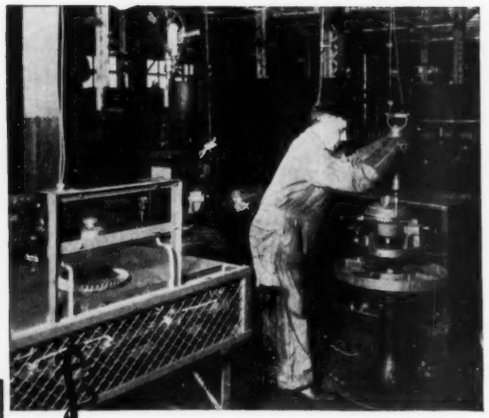

"Strip"

Solves this heating problem

Saves time—cuts rejects

IN the assembly of automobile rear axles at the Columbia Axle Company, it was found necessary to expand steel-ring gears by heat, without warping and with the expansion accurate to 1/1000 of an inch.

"Strip," the G-E strip heating unit, solved this difficult problem. Sixteen "Strips," whose temperature was automatically controlled by a thermostat, were installed under a special cast-iron table top. Now the axles move quickly through the production line and, since warping has been entirely eliminated, there are no rejects.

"Strip," "Spot," and "Dip," and many other G-E electric heating units and devices, will quickly and easily solve dozens of your heating problems. They cost as little as $1.75 each. They are described and priced in the G-E mail-order catalog. If you haven't a copy, send this coupon to the nearest office of your power company, or to General Electric, Dept. 6B-201, Schenectady, N. Y.

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Please mail me a free copy of the General Electric mail-order catalog, GEA-1520B, on small electric heating units.

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Efficient, trouble-free transformers require careful, experienced engineering and special manufacturing facilities which ACME has developed over many years of specialization. Whether you use standard transformers or transformers of special electrical characteristics or mechanical limitations, ACME can serve you economically.

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The suspension type Neon Tube transformer illustrated was developed by ACME to fill a definite need for an attractive, noiseless, and practical transformer for Neon Window tube installations.

ACME

THE ACME ELECTRIC AND MANUFACTURING COMPANY

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"CHACE supplies the ACTIVE ELEMENT in our AUTO-CHECK Draught CONTROL!"

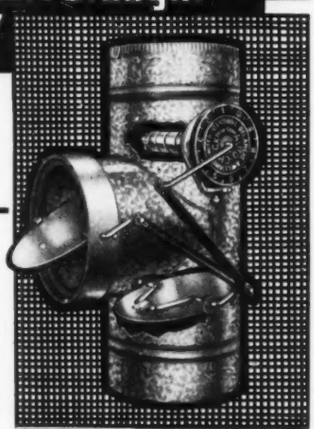
AUTO-CHECK is made for home heating control purposes by:

DELAMERE & WILLIAMS Limited

Toronto Canada

If your problem is a matter of automatically controlling temperature or one where it is desired that the slightest change in temperature shall automatically work a switch, signal or control, then Chace Thermostatic Bimetal used as the active element will assure you reliable and economical service.

Sold in Sheets, Strips and in Shapes formed to own specifications.



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■ Made with the same uniform reliable base cloth as used in IMPERIAL tracing cloth.

But has a special dull drawing surface on which lines made even with a hard pencil, appear sharp and opaque.

As suitable for ink work as the well-known IMPERIAL tracing cloth.

Pencil lines will not smudge, but erasures can be easily made without damaging its surface.

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REG. U.S. PAT. OFF.

for Sale by
LEADING Stationery and Drawing Material Dealers ✦✦ EVERYWHERE

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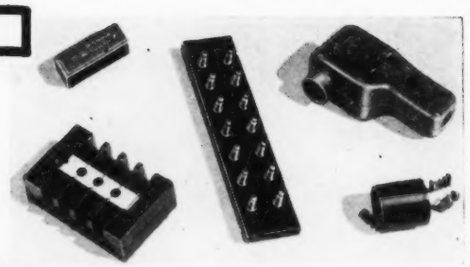

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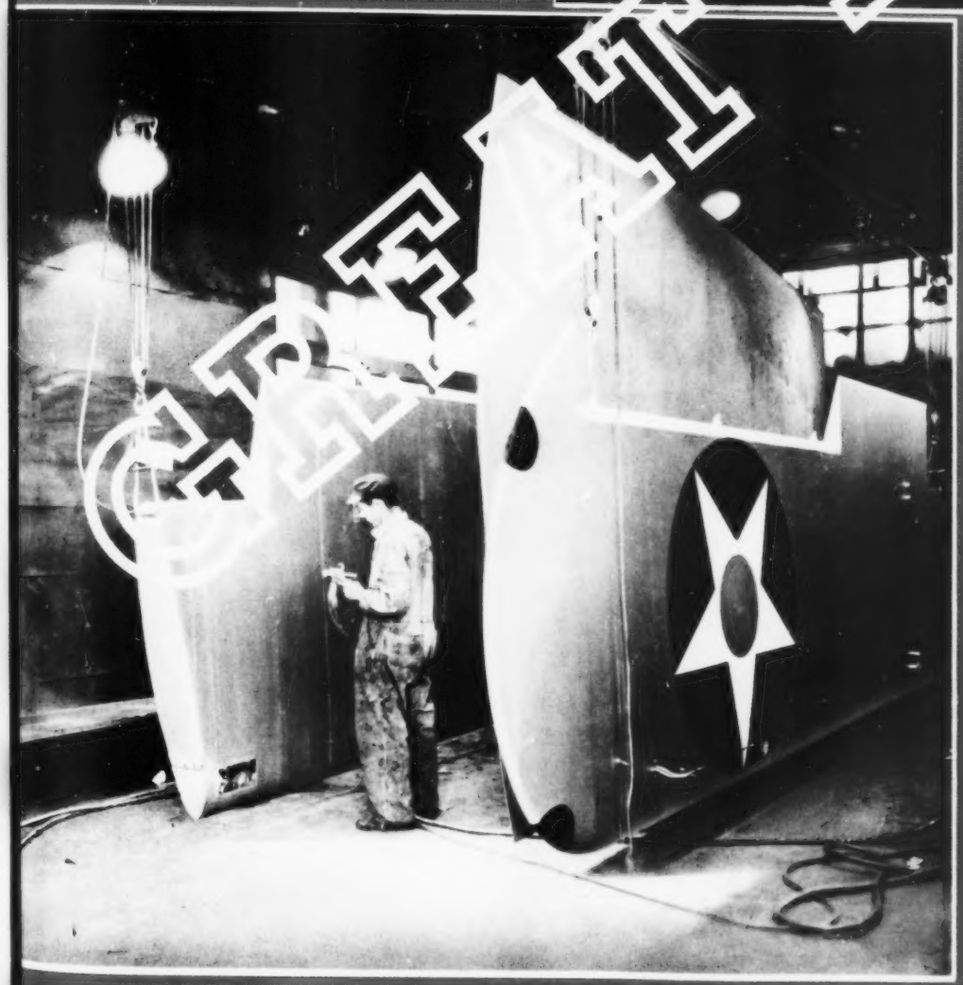
● Only the surest workmanship; only the finest materials . . . aviation's never ceasing demand. Sherwin-Williams finishes for the aviation industry are formulated to meet even more stringent requirement. They have flown millions of miles and have stood up in a fashion befitting the organization and research behind them. Not only finishes but the paint engineering service that Sherwin-Williams offers the aviation industry is of the same superior type. Be sure to see that the Sherwin-Williams paint engineer helps you to establish lower costs through the use of the best finishes obtainable.



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● Fabric Finishes . . . Metal Finishes . . . Wood Finishes . . . Dopes . . . Thinners . . . Primers . . . Lacquers . . . Enamels . . . Your finishing problems can be or already have been solved by Sherwin-Williams paint engineers. They are interested in your costs, your quality and in furnishing the finishes that will be the best for both.

See the Sherwin-Williams Paint Engineer

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INDUSTRIAL FINISHES

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COVER THE EARTH

SHERWIN-WILLIAMS PAINTS

HIRAM WALKER

PEORIA, ILL.

All structural steel and iron work at the world's largest distillery, Hiram Walker's at Peoria, Ill., is protected with Sherwin-Williams Kromik Metal Primer and with Metalastic Field Coat. It's a huge job—it *must* be, to thoroughly protect a plant of such proportions. It covers 22 acres of ground, has a daily capacity of 100,000 gallons and a bottling capacity of 10,000 cases of quarts every 7-hour day. Much of the painting had to be carried on during adverse winter weather conditions, but thanks to the good paint and good painting (Val Jobst and Son were the contractors), an outstanding job was done. Some four thousand tons of structural steel, as well as 2,000 tons of plate employed in tank construction, were given a prime and finish coat. Both Hiram Walker and Sherwin-Williams are proud of the job.

FREE BOOKS

Check the Sherwin-Williams painting booklets most interesting to you. They will be promptly forwarded.

1 Plant Interiors.
2 Plant Exteriors.
3 Metal Protection.
4 Product Finishing—Metal.
5 Product Finishing—Wood.
6 Bus Finishing.
7 Truck Finishing.
8 Aluminum Paint.

Name.....

Company.....

Position.....

Address.....

PHILCO

PHILADELPHIA, PA.

A visit to the Philco Radio and Television Company's plant in Philadelphia is a visit to a beehive. Production is at higher levels than ever before. In the cabinet plant Sherwin-Williams lacquers are part and parcel of this beehive activity. Fillers, first coats, second coats, and soft transparent finishing lacquers are part of the preparation of the finished Philco that may grace your home. You would be amazed at the hand finishing that goes into each cabinet—amazed also at the speed and dispatch with which cabinets are turned out.

BETTER LIGHT BETTER SIGHT

NEW YORK CITY

On the authority of the Better Vision Institute, 85% of all we know comes to us through eyes. Our working and living depend upon them. How to aid them to the fullest? With light, enough light. How to get enough light? See that daylight and artificial light are reflected to the fullest extent. How to do this? As Beechnut Packing, Kendall Mills, Breyer's Ice Cream and other industrial leaders do it . . . by seeing that wall and ceiling surfaces are painted with Save-Lite Mill White.

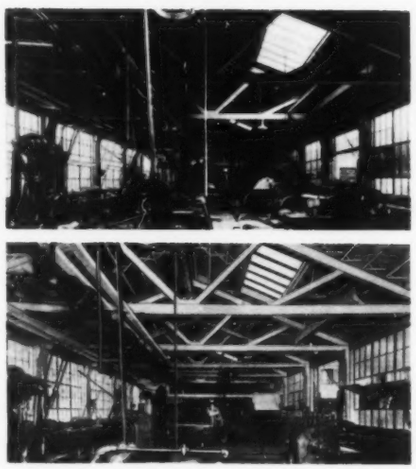
SAVE-LITE

SAVE SIGHT

"Specially formulated for your industry." These five words cover a wealth of experience, research and production. You may have a fume resisting problem; a dust retention problem. You may need a paint that is heat resistant. In your industry a washable gloss may be vital; in someone else's an egg-shell combination of the properties of gloss and flat wall paints is equally necessary. Perhaps you don't know the proper paint for your application. The five words mentioned cover all of the years of The Sherwin-Williams Company's efforts on all paint problems. Breadth of experience means specific answers to your individual problems.

RAFTER

BELLEVILLE, N. J.



Saving light and sight with another Sherwin-Williams Save-Lite job. Rafter Machine Co., Belleville, N. J.

ANSWERS

1 White paint has the highest light reflection value—much higher than aluminum.

2 White paint also has a higher heat reflection value than any other. This means vital saving in gallonage losses of volatile liquids exposed to the sun's rays or other high heat sources.

3 The Mauretania, crack English liner, made heat tests on two Caribbean cruises. When the hull was painted white, the ship was ten degrees cooler than under ordinary dark colors.

4 Westinghouse Electric and Procter and Gamble put all maintenance painting on a time-study and production basis. The savings ran into thousands of dollars yearly.

5 Watch color. It is going to be used to an ever-increasing extent in painting.

6 Be sure to know how to prepare a surface for paint as well as how to paint it. Sherwin-Williams paint engineers will give you good counsel in this regard.

THE SHERWIN-WILLIAMS CO.

ADMINISTRATION OFFICES: CLEVELAND, OHIO

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World's Largest Manufacturer of Paints, Varnishes, Lacquers, Enamels and Stains

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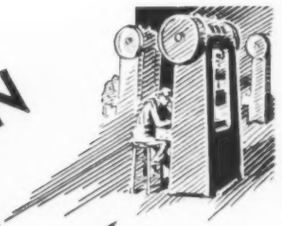

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to

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otherwise
overlooked
—*in cost*
per piece
at each
individual
machine

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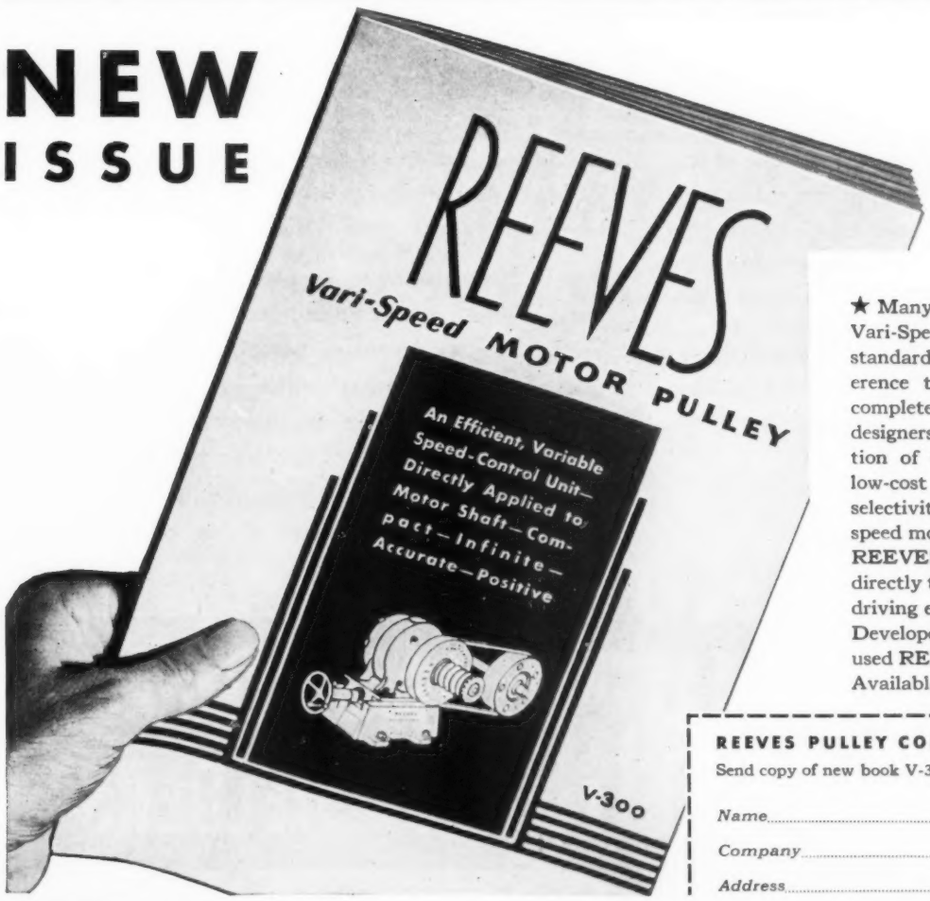
NEW ISSUE



Send for your copy of this valuable Reference Book

★ Many new examples of how the **REEVES** Vari-Speed Motor Pulley is being used as standard equipment. New time-saving reference tables, blue prints, etc., supplying complete engineering information for machine designers. Fully describes design and operation of this simplified, extremely compact, low-cost unit which provides *infinite* speed selectivity over a 3:1 ratio for any constant speed motor from fractional to 7½ H. P. The **REEVES** Vari-Speed Motor Pulley is applied directly to regular motor shaft, forming actual driving element between motor and machine. Developed by manufacturers of the widely used **REEVES** Variable Speed Transmissions. Available in seven sizes.

REEVES PULLEY COMPANY, COLUMBUS, INDIANA

Send copy of new book V-300 on REEVES Vari-Speed Motor Pulley.
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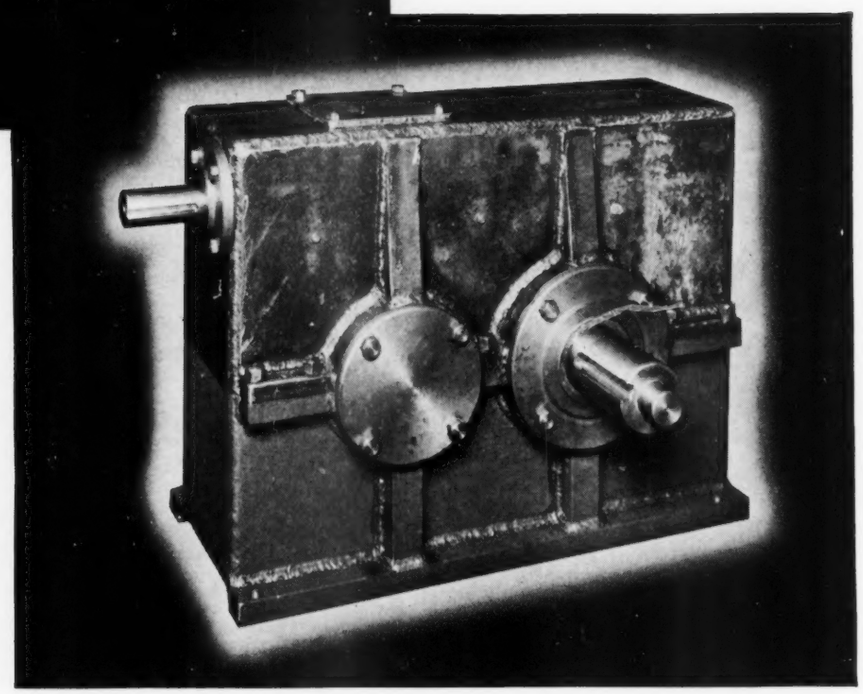
A CASE



OF REDUCTION

in time and cost by "Shield-Arc" welding

Tuesday . . . a failure of the original cast case of this speed reducer shut down an entire manufacturing process. A week to ten days for a new pattern plus added days for casting a stronger case, reported the equipment manufacturer.

In 40 hours half a ton of rolled steel plates and shapes were cut to size, assembled and *"Shield-Arc"* welded to form a stronger, stiffer speed reducer housing at a cost far less than a casting.

Friday . . . production was resumed.

This is but one of hundreds of typical cases of time and money saved, as well as product improvement, effected by *"Shield-Arc"* welded steel construction of machines and machinery parts.

The speed reducer manufacturer, like many other machinery builders, took advantage of every possible saving by welding with a *"Shield-Arc"* welder. It allowed him to get the most out of welding—for *"Shield-Arc"* welds faster. Makes better welds. Uses less power. Puts more of the electrode into the weld.

Eleven distinctive features of the *"Shield-Arc"* welder make it give you more weld per dollar . . . and better welds. That's why more Lincoln welders are in use today than any other make. And why many are scrapping their old type machines for *"Shield-Arcs."* Find out how much *"Shield-Arc"* welders can save you. Ask The Lincoln Electric Company, Cleveland, Ohio. Largest Manufacturers of Arc Welding Equipment in the World.

W-89

LINCOLN "SHIELD-ARC" WELDERS

HAVE you ever wondered why some anodes corrode smoothly and evenly to a mere "stiletto," while others honeycomb apart long before they are used up? The answer is — GRAIN STRUCTURE! Specimen "A", below, has a fine, even grain with no porosity to admit acid between crystals. The corrosion was entirely on the surface—hence its evenness. In specimen "B", the crystals were separated by impurities which, under electrolytic action, dropped to the bottom of the tank and formed sludge (waste)! If action had been continued a little longer, the undermining would have met itself and severed the anode.

Seymour Nickel Anodes give 100% deposit because the grain structure is homogeneous. Nothing is used but virgin nickel. This is melted in a modern, electric furnace and poured under accurate pyrometric control — after which the mix is tested in the laboratory for crystallization. Every anode has a fine grain structure of correct analysis and will stay on the hook until complete corrosion has taken place.

Seymour Nickel Anodes (sand cast, iron mold or rolled depolarized) are made in 90-92%, 95-97% and 99 + carbon type, and in 99 + oxide type, in over 250 patterns. Your preference is always available in Seymour "Controlled Grain" Anodes. If you think you are not obtaining full service from your anodes, send us one for free metallurgical and physical examination. (Seymour Anode Book on request.)

DO YOUR ANODES WEAR LIKE THIS?

OR THIS?

THE SEYMOUR MANUFACTURING CO., 33 FRANKLIN ST., SEYMOUR, CONN.

SEYMOUR

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NICKEL ANODES

ALSO ANODES OF BRASS, BRONZE, COPPER, ZINC

Specialists in Nickel Silver and Phosphor Bronze

BEARINGS PROTECTED BY

CHICAGO RAWHIDE "PERFECT" OIL RETAINERS

SHOW BETTER

PERFORMANCE AND LONGER SERVICE

The bearings on 89% of all automobiles built in the United States today operate under the protection of the "Perfect" Oil Retainer. This lubricant seal is used on pinion shafts running at 1000 peripheral feet per minute or more where high heat and excessive oil pressure are unavoidable. Transmission and propeller shaft bearings, together with the front and rear engine seals, operate under similar conditions and are protected in the same way.

Other automotive applications include the outer wheel bearings, the fan bearings, the water pump bearings and the steering gear bearings.

A Chicago Rawhide Oil Retainer not only holds securely the lubricant in the adjacent bearing but also prevents oil and grease leakage through that bearing from within the mechanism.

Machinery bearings of all types retain their adjustment and operate considerably longer when adequately protected against lubricant leakage and against the entrance of moisture and foreign matter from outside the housing.

Ask Chicago Rawhide Engineers for their suggestions on your bearing problems.

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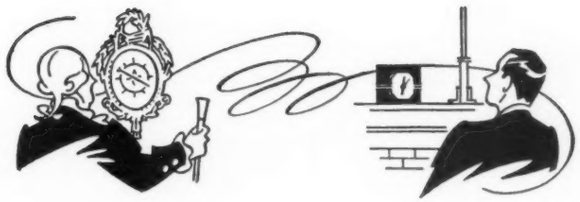

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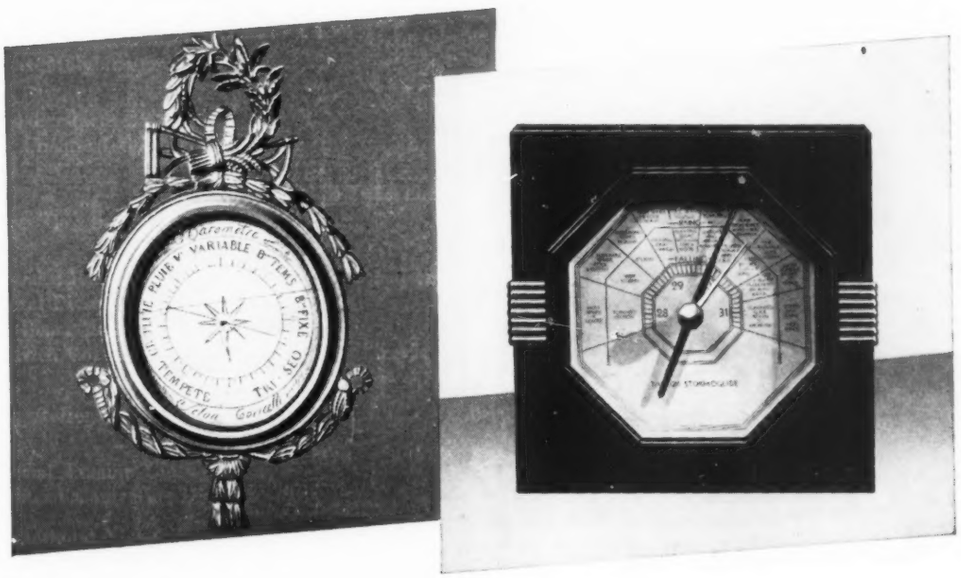

IN THE DAYS of Louis XVI a barometer was a rare and costly instrument worthy of a case hand wrought by the most skilled of artisans. Today, barometers of far greater accuracy also have cases by talented artist designers, but they are produced of Bakelite Molded by the thousands and sold for a few dollars.

Today, perhaps as never before, people have an appreciation of beauty, even in articles of utility. Within the few years since artist designers first undertook product design, it has been demonstrated time and time again that pleasing design is an important and measurable aid to greater sales. These same designers also have found that the use of Bakelite Materials makes practical the economical reproduction of their designs.

These Bakelite Materials, both molded and laminated, possess many valuable properties. They are strong, hard, resistant to moisture and to temperature and atmospheric conditions; they do not deteriorate with age and their finish is durable; they are readily adaptable to the accurate and economical reproduction of almost any design, and are available in black and many colors. When you are undertaking product redesign or the development of new products we invite you to consider the advantages of Bakelite Materials and to enlist our cooperation. We also would be glad to have you write for copies of our informative illustrated booklets **5M**, "Bakelite Molded" and **5L**, "Bakelite Laminated".

★

Illustration shows Louis XVI barometer of carved, gilded wood; and Taylor Stormoguide with Bakelite Molded case, designed by Walter Dorwin Teague.

BAKELITE CORPORATION, 247 Park Avenue, New York, N.Y.....43 East Ohio Street, Chicago, Ill.
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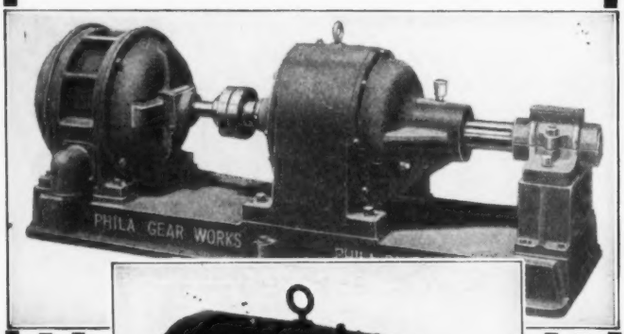

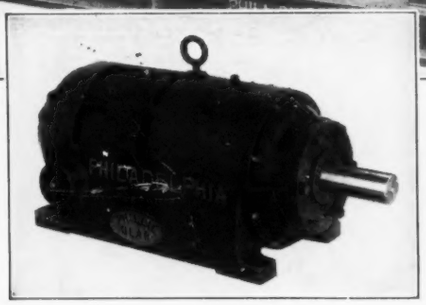

Consider the Space Saving possible with the MOTOREDUCER

The Philadelphia MotoReduceR is a built-in motor and speed reducing unit that offers considerable saving in space over that required by separate units. The base plate is eliminated, and the coupling between the motor and speed reducer is also discarded. The MotoReduceR, when included as a part of a machine design, will fit in spaces that would not accommodate the older type of drive. Its sturdiness of construction and absolute dependability in operation, plus the lack of attention required when in use (only a very occasional oiling), adds a strong selling point to any new product on which it is included. As it is built in both horizontal and vertical types, its adaptability is almost limitless.

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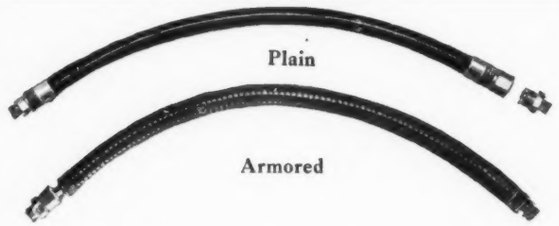

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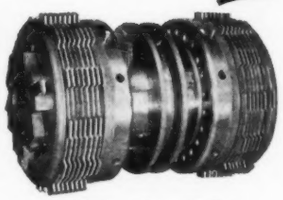
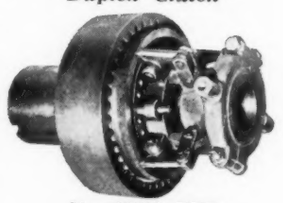


Close Coupled Duplex Clutch



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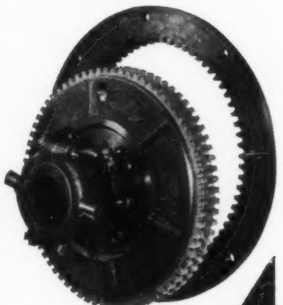

No. 7174-GT Gear Tooth Power Take-Off Unit

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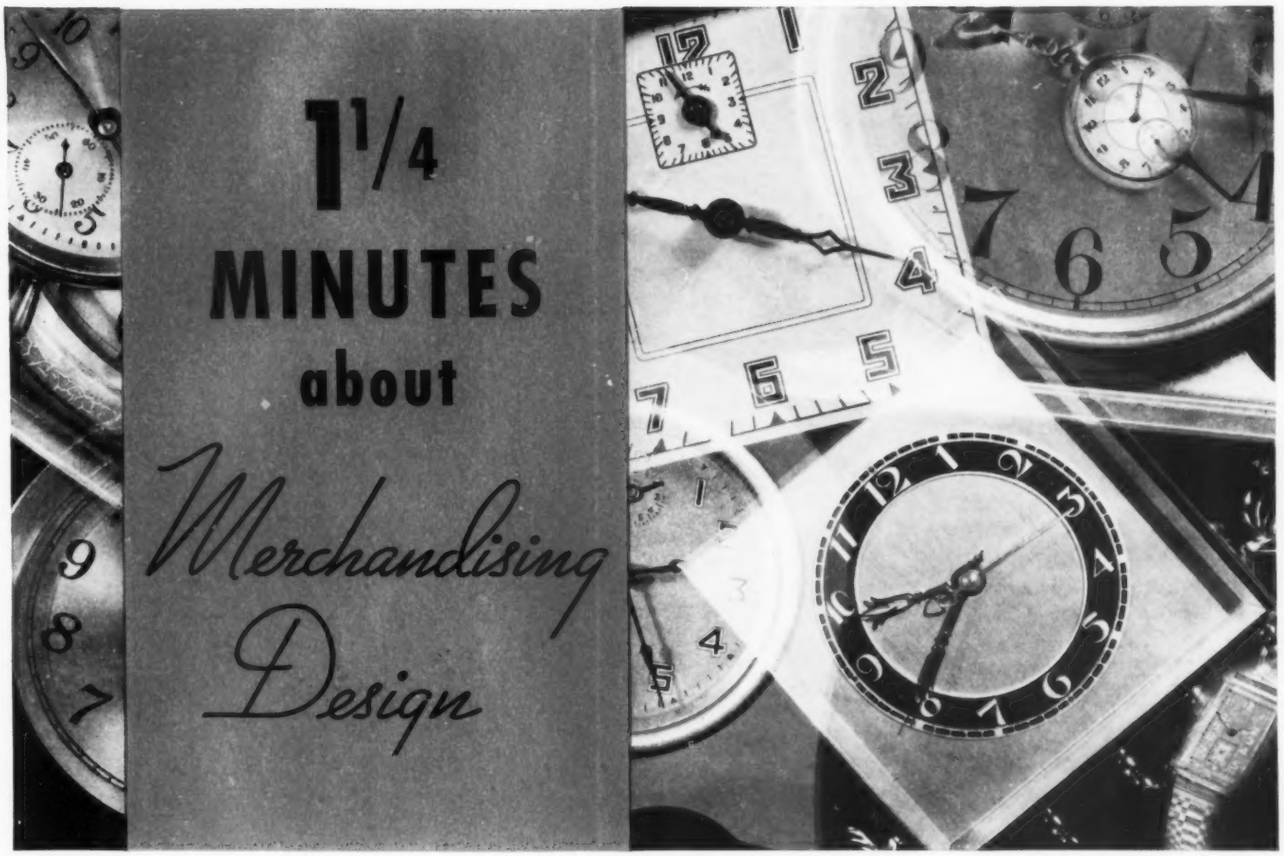

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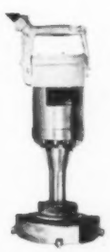
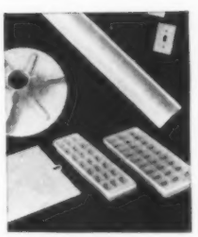
Alcoa Aluminum is *the* all-purpose metal in modern design and redesign. It helps solve the problem of combining pleasing appearance with superior performance.



The artistic aspects of *line* and *form* find an ideal solution in the facility with which Alcoa Aluminum may be made to follow the finest detail of design whether it be cast, or formed.



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[● There is nothing elsewhere in this advertisement to remind you that Alcoa Aluminum has the tensile strength of structural steel, with 1/3 the weight.]

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